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DESTRUCTIVE AND USEFUL INSECTS

THEIR HABITS AND CONTROL

C. L. METCALF

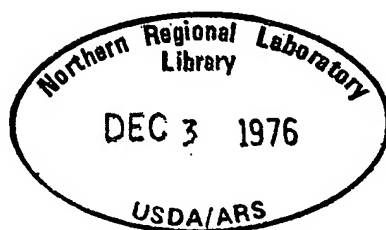
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DESTRUCTIVE AND USEFUL INSECTS

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STEPHEN A.
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THE PHYLUM ARTHROPODA

In Chapter 3 the important structural and functional characteristics of insects were described. No single one of these characteristics will define an insect and distinguish all insects from all other kinds of animals. For example, the *segmented body, bilateral symmetry, paired jointed appendages* usually terminating in claws, *chitinous exoskeleton, ventral nervous system, and dorsal heart* are the characteristics of the entire phylum Arthropoda, which includes besides the true insects many other creatures such as crayfish, crabs, lobsters, sowbugs, centipedes, millipedes, spiders, mites, ticks, scorpions, harvestmen, and many others. The phylum Arthropoda is the largest phylum in the animal kingdom and, aside from the vertebrates, the phylum of most importance to man. This phylum embraces five important and well-known classes, of which insects (the class Hexapoda) is one (Table 6.2). More than 75 per cent of all the animal kinds hitherto found and named belong in the phylum Arthropoda, and about 90 per cent of these are true insects. The class Hexapoda is further analyzed in this chapter, and, except for a number of references to mites and ticks, the remainder of this book is devoted to a discussion of important insects.

TABLE 6.2. THE PHYLUM ARTHROPODA

Classes	Examples	Estimated Number of Living Species Described
Hexapoda (Insecta)	All true insects.....	686,000
Chilopoda	Centipedes or hundred-legged-worms...	1,200
Diplopoda	Millipedes or thousand-legged-worms...	1,300
Arachnida		
Orders of the		
Class Arachnida		
Scorpionida	Scorpions.....	600
Phalangida	Harvestmen or daddy-long-legs.....	1,900
Araneida	Spiders.....	22,000
Acarina	Mites and ticks.....	9,200
Minor orders	Pedipalpa, Pseudoscorpionida, Solpugida, Palpigrada.....	2,500
	Total Arachnida.....	36,200
Crustacea	Crayfish, lobster, crab, sowbug, barnacles, water fleas, cyclops.....	25,000
Minor classes	Paupoda, Symphyla, Pycnogonida, Xiphosura, Linguatilida.....	1,250
	Total.....	750,950

The possession of three pairs of legs, three body regions, and wings are characteristic things that mark off the insects from the other arthropods. Each of the four other classes is distinguished by certain structural features not possessed (at least in their entirety) by the rest of the arthropods. In common usage, many of the representatives of these other classes are considered to be "bugs," and the species of economic importance are dealt with chiefly by entomologists. Hence a brief discussion is given here of the classes Chilopoda, Diplopoda, Arachnida, and Crustacea (Table 6.2).

Class Chilopoda: The closest relatives of the true insects are the centipedes, which have a single pair of antennae, the posterior end of the body is not flattened, and in the large compound eyes are rarely true worms in having a dorsal heart. There are many species of centipedes, especially the large ones, which sometimes inflict very painful bites.

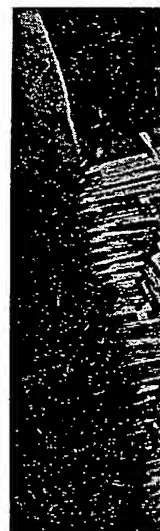


FIG. 6.1. A giant centipede. Note the size as compared with the insect.

Class Diplopoda: The millipedes are superficially much like centipedes, but their legs are still more numerous, often exceeding two pairs of legs. There are no poison legs; the mouthparts are forward close to the head, but some species attack leaves that lie close to the ground. They may be serious pests in fields and gardens, and have an offensive odor.

Class Arachnida: The spiders are the largest class of Arachnida. They have four pairs of legs, mites, ticks, and harvestmen are smaller. They have Malpighian tubes. They have no antennae, true jaws.

¹ Care should be taken to give the name of the phylum, Arthropoda, at the beginning.

Class Chilopoda: The Centipedes or Hundred-legged-worms (Fig. 6.1). The closest relatives of the true insects are the centipedes. Like the insects, they have a single pair of antennae, they breathe by tracheae, and the reproductive organs open at the posterior end of the body. They differ from insects in having neither thorax nor wings and in the large number of legs, typically one pair to each body segment. Compound eyes are rarely developed. They are worm-like in form but differ from the true worms in having a distinct head and definite jointed legs. They are usually somewhat flattened. There are a pair of poison claws or legs, on the first segment behind the head, that are used to paralyze insects and other prey that they devour. The centipedes may as a group probably be considered beneficial, although some of the species, especially the larger ones, which in the tropics may reach a length of 18 inches, sometimes inflict very painful bites upon man.

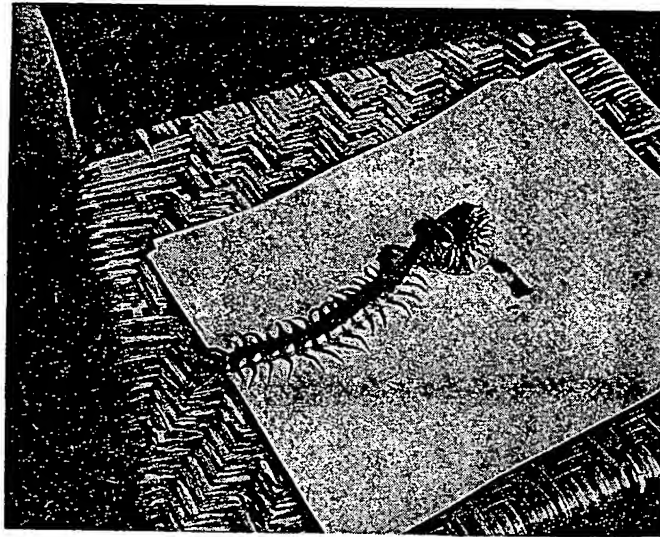


FIG. 6.1. A giant centipede from the southeastern United States, feeding on a white grub. Note the size as compared with chair. (Photograph from life by A. R. Cahn.)

Class Diplopoda: The Millipedes or Thousand-legged-worms. Millipedes are superficially much like centipedes but differ in the following important respects. The legs are still more numerous than in the centipedes, each apparent body segment having two pairs of legs. The body is typically round in cross-section, not flattened; there are no poison legs; the antennae are short; and the reproductive organs open far forward close to the head. The millipedes generally feed on decaying vegetable matter but some species attack growing crops in damp soil, eating either the roots or the leaves that lie close to the ground. They are sometimes mistaken for wireworms and may be serious pests in fields and greenhouses (page 884). Many of the species have an offensive odor.

Class Arachnida: The Spiders, Ticks, and Their Relatives. Next to the insects, the largest class of Arthropoda is the class Arachnida,¹ to which the spiders, scorpions, mites, ticks, and harvestmen belong. The Arachnida resemble insects in their small size, in their predominantly terrestrial habits, and in the possession of tracheae and Malpighian tubes. They differ radically, however, in having four pairs of legs; in having no antennae, true jaws, or compound eyes; in having only two body regions, the

¹ Care should be taken not to confuse the name of this class, *Arachnida*, with the name of the phylum, *Arthropoda*, since the names somewhat suggest each other to the beginner.

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head and thorax being grown together into one region; in the curious "book-lungs" used for respiration; in not having a conspicuous metamorphosis; and in the position of the openings from the reproductive organs which are near the front of the abdomen. There are a number of orders in this class of which the following need mention here.

Class Arachnida: Order Araneida. This large order includes all the spiders—a group of animals rivaling the snakes in their ability to frighten people. Comstock, the author of "The Spider Book," has well said: "Few groups of animals are more feared, and few deserve it less." All spiders have a pair of venomous jaws and live on insects which they poison with their bites. They can bite; and occasionally such bites may become infected and cause serious results. But probably in all the world there are not more than a few species, if any, that are capable of killing man by their bites. The large "tarantula" (Fig. 6.2), which comes into our midst in bunches of bananas, is capable of killing birds and small mammals by its bite. It apparently cannot kill a

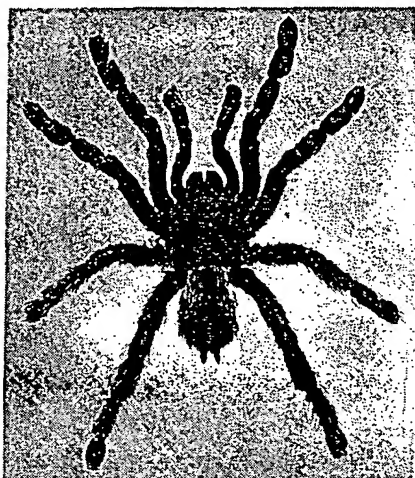


FIG. 6.2. Tarantula. About $\frac{1}{2}$ natural size. (From Herrick, "Insects Injurious to the Household," copyright, 1914, Macmillan. Reprinted by permission.)

man, and besides it seems hard to persuade to bite a person, as has been shown by the experiments of Baerg.¹ Among our native spiders, the one having the worst reputation is the "hourglass spider" or "black widow," *Latrodectus mactans* (page 1008).

One of the most characteristic things about spiders is their habit of spinning silk. This is used in a variety of ways. (a) Chiefly it serves as a snare to capture food. It is truly a wonderful thing for a dumb animal to manufacture and set a trap. We know of none of the higher animals except man that do this, although it is done by some of the insects. (b) It forms tubes or tents for protection. (c) It forms sacs for protection of the eggs and newly hatched young. (d) It is used for locomotion. Spiders descend from higher to lower levels by spinning out a thread as they let themselves slowly down. Some spiders climb to a high point, and resting on their front legs begin to spin silk, supporting it by the hind legs until the loose end is caught by the breeze.

More and more is thrown out until finally this simple kite exerts pull enough to carry the spider away. This can usually be observed in the open country on any bright autumn day, and the threads of "ballooning" silk, revealed by the descending sun, often seem to carpet the grass.

Class Arachnida: Order Acarina (Fig. 6.3). Mites and ticks can usually be told at a glance from spiders or insects, because the body is all one region, there being little indication of either body regions or segments. They are like the spiders in the matter of appendages, and some of them spin silk. A curious feature is that the newly hatched young have only three pairs of legs. They breathe either by tracheae or directly through the skin. The chief difference between mites and ticks is a difference in size, i.e., the larger members of this order (Fig. 6.3, A) are called ticks, while the smaller ones (B) are called mites.

The economic importance of the mites and ticks is at least fourfold: (a) Some of them injure plants, e.g., the red spider mites (page 616) and the gall mites. (b) A number of species are found on or in the bodies of insects. Some of them are said simply to be riding upon the insects to a new feeding ground, but at least some species are parasitic upon the insects. Thus the Isle of Wight disease among honeybees is caused by a kind of mite that lives in the tracheae of the bee. (c) Many species are

¹ Ann. Ento. Soc. Amer., 18:471, 1925.

parasitic upon other animals, the cattle tick (page 960), the mite (page 991), itch mite (page 993). (d) Many of the parasites are borne on man by the bite of the cattle tick, and spirochetosis by the fowl tick further discussed in the following they injure.

Class Arachnida: Order S western part of the United States are well known at least by name. The sting is borne on the four pairs of walking legs, and the terminal half of it is the size and provided with a pair of pedipalps are used to grasp the back and the stinger plun

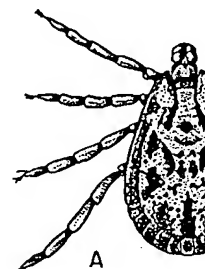


FIG. 6.3. A, the spotted-fever tick of the same order, usually called *Clelandia*.

The young are born after a time after birth. Nocturnal creatures that for insects. Although the stings of a bee or wasp, the venom is neurotoxic and may cause

Class Arachnida: Order Ph are familiar to all out-of-door spiders, but close examination of the waist. The legs are carried within them. The creatures have a narrow and Comstock suggests that this protective adaptation, enabling a leg—minus that leg!

The food of the harvestmen feed largely upon insects, other plant tissues. At any rate the habits.

Class Crustacea: The Crayfish (Figs. 6.5 and 6.6). The crayfish representatives of this class. removed from the insects of a. They have five pairs of walking

curious "book-lungs" is; and in the position front of the abdomen. ng need mention here. ll the spiders—a group ople. Comstock, the imals are more feared, aws and live on insects ionally such bites may the world there are not n by their bites. The bunches of bananas, is pparently cannot kill a it seems hard to per- son, as has been shown ts of Baerg.¹ Among , the one having the the "hourglass spider" " *Latrodectus mactans*

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fourfold: (a) Some of he gall mites. (b) A some of them are said t at least some species e among honeybees is (c) Many species are

parasitic upon other animals, including man. Here the most notorious examples are the cattle tick (page 960), the Rocky Mountain wood tick (page 1017), the poultry mite (page 991), itch mite (page 1025), scab mite (page 979), and scaly-leg mite (page 993). (d) Many of the parasitic species are to be feared because they are the known and only carriers of some animal diseases. Thus Texas fever is transmitted chiefly by the bite of the cattle tick, Rocky Mountain fever of man by the wood tick, and fowl spirochetosis by the fowl tick (Table 1.2). The important species of Acarina are further discussed in the following chapters, in connection with the crops and animals they injure.

Class Arachnida: Order Scorpionida. The scorpions are common in the south-western part of the United States and other subtropical and tropical regions. They are well known at least by name to nearly everyone, because of their reputation as stingers. The sting is borne at the tip of the abdomen. The latter is unusually long and the terminal half of it much more slender than the basal half. In addition to the four pairs of walking legs, scorpions have the pedipalps developed to very large size and provided with a pair of pincers so that they appear to have five pairs of legs. The pedipalps are used to grasp prey, and the abdomen is then curled forward over the back and the stinger plunged into the victim to paralyze it.

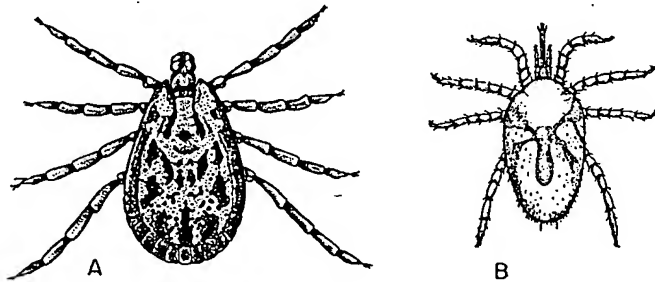


FIG. 6.3. A, the spotted-fever tick (from Cooley) and B, one of the smaller members of the same order, usually called a mite, the tropical fowl mite. Much enlarged. (From Cleveland.)

The young are born after hatching from the eggs, and are carried about by the mother for a time after birth, clinging with their pincers to her body. They are nocturnal creatures that forage about at night, catching and stinging spiders and insects. Although the stings of most scorpions are scarcely more painful than those of a bee or wasp, the venom of *Centruroides sculpturatus* and *C. gertschi* of the Southwest is neurotoxic and may cause severe illness or even death.

Class Arachnida: Order Phalangida (Fig. 6.4). The harvestmen or daddy-long-legs are familiar to all out-of-door persons. They look much like very long-legged spiders, but close examination will show that the body is not divided by a slender waist. The legs are carried with the "knees" high, and the body swung low between them. The creatures have a noticeable odor that probably discourages many enemies, and Comstock suggests that the ease with which the legs separate from the body is a protective adaptation, enabling them to get away from predators that grasp them by a leg—minus that leg!

The food of the harvestmen is not well known. Some authors state that they feed largely upon insects, others that they take only dead insects, soft fruits, and other plant tissues. At any rate they are not known to have any injurious or objectionable habits.

Class Crustacea: The Crayfish, Crabs, Sowbugs, Barnacles, and Their Relatives (Figs. 6.5 and 6.6). The crayfish, lobsters, and crabs are the largest and best known representatives of this class. They are primarily aquatic in habit and furthest removed from the insects of any of the classes of arthropods discussed in this book. They have five pairs of walking legs, paired jointed appendages on the abdomen, two

pairs of antennae, a pair of compound eyes, and only two body regions. The legs are forked or branched into an outer branch, the *exopodite*, and an inner branch, the *endopodite*. The coxopodite, from which these branches arise, usually bears a gill. Unlike insects they have no tracheae and breathe by blood gills or through the skin. The excretory organs lie in the head, opening at the base of the antennae. The reproductive organs open at the base of the walking legs. The forms most likely to be confused with insects are the small terrestrial sowbugs and pillbugs which abound

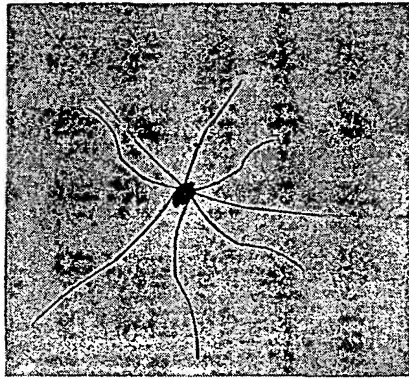


FIG. 6.4. A harvestman or daddy-long-legs. Natural size. (From Slingerland.)



FIG. 6.5. A crayfish about $\frac{1}{2}$ natural size. (From Fernald, "Applied Entomology.")

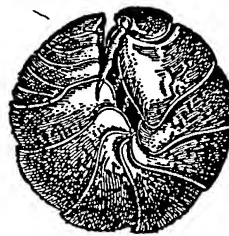
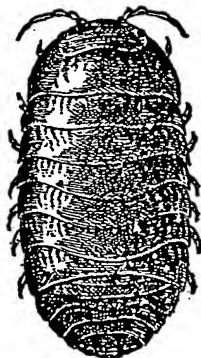


FIG. 6.6. The greenhouse pillbug. Left, extended; right, rolled into a ball. Enlarged. (From U.S.D.A., Farmers' Bul. 1362.)

under boards, logs, in greenhouses, and other damp places. The pillbugs have the habit of rolling themselves into a nearly perfect sphere when disturbed. They are sometimes injurious in greenhouses.

THE ORDERS OF INSECTS

As we have seen in Tables 6.1 and 6.2, about 72-per-cent of all known kinds of living animals are insects. About 686,000 different kinds have been discovered, properly named, and described. Thousands of new

species are being found e reached a full knowledge that are probably living Gossard,¹

"... is variously estimated favoring the latter figure to be correct, in what that he attempts to familiarize it the next time he sees it. at the age of 5 years and allow one-half of the time to a man become lazy, we will provide night and lest he should become snatch mouthfuls from the 5-memory the anatomical changes species from every kindred or nearly 100 summers will have long procession of insects have

Obviously none of us s Obviously, too, no one him, offhand, the name of that it is, in its finer aspects

A good working knowledge the grasp of any earnest s as orders. About 26 orders and these are listed in Table 6.3 Zoraptera are comparatively are unlikely to be encountered apparent economic importance number of other orders but these are generally omitted in Table 6.3 there have contain species of importance

KEYS TO THE

- A. Insects usually provided with thorax, abdomen, and jointed legs; if 1 tarsal segment firm, hard, often highly variable in size; often engaged for siphoning (Fig. 4.10) entirely wanting or functionless
- B. Insects without functional thorax, abdomen, and jointed legs; incapable of transporting themselves; short or entirely wanting (page 213). Tarsi frequently claw. If legs of type shown Sometimes without a distal segment Often enclosed in a case of

A. KEY TO ORDERS

- 1a, Insects with wings. (If wings present)
- 1b—Wingless insects.....

¹ Jour. Econ. Entom., 2:314,

body regions. The legs
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lls or through the skin.
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about $\frac{1}{2}$ natural size.
("Applied Entomology.")



into a ball. Enlarged.

The pillbugs have the
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ifferent kinds have
Thousands of new

species are being found every year, indicating that we are far from having reached a full knowledge of the class Hexapoda. The number of species that are probably living in all parts of the earth, according to H. A. Gossard,¹

"... is variously estimated at from 2,500,000 to 10,000,000, with the probabilities favoring the latter figure as the more nearly correct. Assuming the maximum figure to be correct, in what a field does the entomologist find himself! Suppose that he attempts to familiarize himself with each species so that he will recognize it the next time he sees it. Since his task is obviously great, we will start him at it at the age of 5 years and allot him 5 minutes in which to study each species giving him one-half of the time to a male specimen and one-half to a female. Lest he should become lazy, we will provide him with electric lights and keep him working day and night and lest he should become fat, we will forbid him to eat except as he is able to snatch mouthfuls from the 5-minute intervals during which he is expected to fix in his memory the anatomical characters, color patterns, etc., which differentiate each species from every kindred one. Working in this manner and at this rate, the rains of nearly 100 summers will have fallen on his roof before the last representative of the long procession of insects has passed before him."

Obviously none of us shall ever learn to know all of the kinds of insects! Obviously, too, no one need be surprised if an entomologist cannot tell him, offhand, the name of every insect encountered. The field is so vast that it is, in its finer aspects, beyond the comprehension of any one man.

A good working knowledge of the groups of insects, however, is within the grasp of any earnest student. The largest groups of insects are known as *orders*. About 26 orders are commonly recognized by entomologists, and these are listed in Table 6.3. Of these the Protura, Embioptera, and Zoraptera are comparatively rare and contain so few species that they are unlikely to be encountered by any save the specialist. They are of no apparent economic importance and will not be discussed further. A number of other orders contain many common and interesting species, but these are generally of no great importance to man. From the orders in Table 6.3 there have been selected for special study 13 orders which contain species of importance to man; these are printed in boldface type.

KEYS TO THE PRINCIPAL ORDERS OF INSECTS

- A. Insects usually provided with 1 or 2 pairs of wings and capable of flying. Head, thorax, abdomen, and jointed legs nearly always distinct. Tarsi generally of more than 1 segment: if 1 tarsal segment and 1 claw, see page 226. Body wall generally firm, hard, often highly colored. Individuals nearly always active, with little variation in size; often engaged in mating or egg laying. Mouth parts often modified for siphoning (Fig. 4.16), lapping (Fig. 4.17), or sponging (Fig. 4.15), sometimes entirely wanting or functionless. Adult Insects, see A, couplet 1a, 1b.
- B. Insects without functional wings, either entirely wingless or with short wing pads incapable of transporting the body. Legs sometimes normally developed, but often short or entirely wanting. Rarely entirely sessile or incapable of locomotion (page 213). Tarsi frequently consisting of a single segment and bearing a single claw. If legs of type shown in Fig. 3.4,E, and no exposed mouth parts, see couplet 7. Sometimes without a distinct head, often the thorax not distinct from abdomen. Often enclosed in a case of some kind. Immature Insects, see B, couplet 41a, 41b, 41c.

A. KEY TO ORDERS OF INSECTS IN THE ADULT STAGE

- 1a, Insects with wings. (If wings very short, try also couplet 41a and 41c).....20.
1b—Wingless insects.....2.

¹ *Jour. Econ. Ento.*, 2:314, 1909.

TABLE 6.3. THE ORDERS OF THE CLASS HEXAPODA

Types of Mouth Parts	Orders	Examples	Estimated Number of Species Described ¹	Number of Wings in Adult		
				World	North America North of Mexico	North America North of Mexico
Chewing in nymphs and in adults	Protura	Telsontails	90		29	
	Thysanura	Bristletails, silverfish	700		50	No wings
	Collembola	Springtails	2,000		314	
	Orthoptera	Without Metamorphosis Primitively Wingless				
		Wings Develop Externally on Nymphs Which Have Compound Eyes				
		Roaches, crickets, grasshoppers, katydids, mantids, walking-sticks	22,500	1015		
	Dermaptera	Earwigs	1,100	18		
	Embioptera	Embiids	149	8		Four wings (rarely none)
	Ephemeroptera	Mayflies	1,500	550		
	Odonata	Dragonflies, damselflies	4,870	412		
Rasping-sucking in nymphs and in adults	Plecoptera	Stoneflies	1,490	340		
	Isoptera	Termites, "white ants"	1,717	41		Four wings or none
	Corrodentia	Book-lice, bark-lice	1,100	120		
	Zoraptera	Zorapterans	19	2		
	Mallophaga	Chewing lice, bird lice	2,675	318		No wings
	Thysanoptera	Thrips	3,170	606		Four wings or none
	Homoptera	Aphids, scales, cicadas, leafhoppers	26,500	8,742		
	Hemiptera	True bugs	28,500			
	Anoplura	Bloodsucking lice	250	62		No wings
		Wings Develop Internally in Larvae Which Do Not Have Compound Eyes				
Chewing in larvae and in adults	Coleoptera	Beetles, weevils	277,000	26,576		
	Strepsiptera	Twisted-wing parasites	300	100		
	Neuroptera	Lacewings, ant-lions, dobson flies	4,670	338		Four wings (rarely none)
	Mecoptera	Scorpion-flies	350	66		
	Trichoptera	Caddis-flies	4,450	921		
Chewing in larvae, siphoning in adults	Lepidoptera	Butterflies and moths	112,000	10,300		
		Chewing or reduced in				

Rasping-sucking in nymphs and in adults	Isoptera	Termites, "white ants"	340/
	Corrodentia	Book-lice, bark-lice	1,490
	Zoraptera	Zorapterans	1,717
	Mallophaga	Chewing lice, bird lice	1,100
	Thysanoptera	Thrips	19
Piercing-sucking in nymphs and adults	Homoptera	Aphids, scales, cicadas, leafhoppers	2,675
	Hemiptera	True bugs	3,170
	Anoplura	Bloodsucking lice	26,500
			28,500
			250
			62 No wings

With Complete or Complex Metamorphosis

<i>Wings Develop Internally in Larvae Which Do Not Have Compound Eyes</i>			
Chewing in larvae and in adults	Coleoptera	Beetles, weevils	277,000
	Strepsiptera	Twisted-wing parasites	26,576
	Neuroptera	Lacewings, ant-lions, dobson flies	300
	Mecoptera	Scorpion-flies	4,670
	Trichoptera	Caddis-flies	350
Chewing in larvae, siphoning in adults	Lepidoptera	Butterflies and moths	4,450
			112,000
			10,300
Chewing or reduced in larvae; chewing or chewing-lapping in adults	Hymenoptera	Bees, wasps, ants, sawflies	103,000
			14,528
Chewing or reduced in larvae; piercing- sucking or sponging in adults	Diptera	Flies, mosquitoes, gnats	85,000
			16,700
Chewing in larvae and piercing-sucking in adults	Siphonaptera	Fleas	1,100
			238
Total insects			686,200
			82,394

¹ Modified from SABROSKY, C., *U.S.D.A., Yearbook*, 1952.

pair of wings (the front pair) developed for flight, and each of the hind wings reduced to a short, slender thread, with a knob at the end of it (Fig. 6.96). These rudimentary second wings are called *halteres* or balancers. There is some evidence that they are orienting organs, serving to keep the insects balanced. A few other insects have a single pair of wings, such as certain beetles and May-flies, but these never possess halteres. Many of the Diptera are wingless, having lost the first pair of wings; but even then the halteres usually remain, so that the possession of halteres is perhaps the most distinctive thing about this order. The front pair of wings is similar to those of bees and wasps in texture, i.e., transparent and with comparatively few veins, as a rule. They are small in comparison with the size of the insect, a condition associated with very swift flight. While usually clear, they may have a color pattern (Fig. 6.108), and sometimes the veins are bordered with scales.

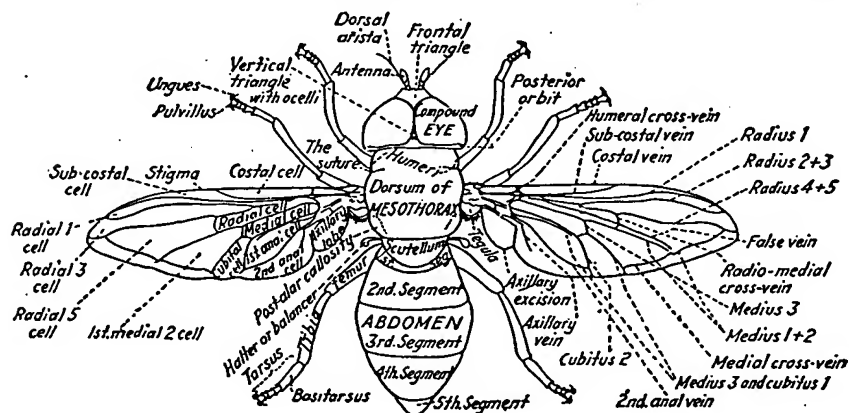


FIG. 6.96. Dorsal view of a male syrphid fly to show names of the principal parts of the body. Some authors use *alula* or *squama* instead of *tegula*. (From Melcalf, Ohio Biol. Surv. Bul. 1.)

The three body regions are very distinct in Diptera. The head is large, often hemispherical, and attached to the thorax by a very slender stem or neck. By reason of the fact that only the front wings are functional, the thoracic mass is largely made up of the mesothorax. A small, distinct, semicircular part of the mesothorax overhanging the base of the abdomen is called the *scutellum*. The abdomen is of varied shape, usually shows from four to nine segments, and the cerci, ovipositor, and male genitalia are normally introverted or retracted, so as to be invisible without special preparation.

The mouth parts of adult Diptera are rather varied in form. Two distinct types are represented; the piercing-sucking type and the sponging type (pages 142, 145). There are several varieties of the former, called subtypes (Figs. 4.7, 4.8, and 4.15). So far as known, no adult fly masticates solid foods; and few, if any, pierce plants to suck the sap. The majority probably feed upon the nectar and pollen of flowers; many others depend upon liquid organic matter such as that from decomposing plant or animal bodies, flowing sap, and honeydew; or they dissolve solid substances in their saliva, e.g., sugar, and sponge up the solution. A number of species are predaceous on other insects, sucking the juices from their bodies.

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The females of hundreds of species, representing at least eight families, suck the blood of warm-blooded animals, and, in the Muscidae and Hippoboscidae, the males also have this bad habit. There are many

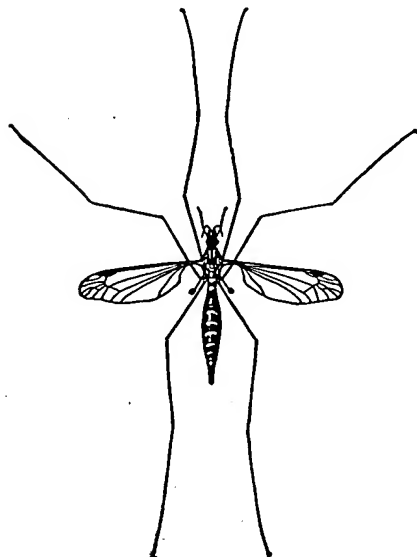


FIG. 6.97. A crane fly or tipulid, male. (From Sanderson, "Insect Pests," after Weed.)

adults that take no food whatever, this life-stage generally being short and occupied almost exclusively with the business of getting the eggs developed, fertilized, and laid. The metamorphosis is complete or complex. The larvae are well separated from the adults both structurally and in habits and specialized to a more extreme degree than the larvae of any other order. There are very few cases where the larvae and adults live together and partake of the same kind of food, as is so common among the beetles. The larvae are always legless and in the larger part of the order have no distinct head (Figs. 2.15,C, and 4.18). In those species where the head is distinct, mosquitoes, for example (Figs. 5.15,E,G, and 21.1), the mouth parts of the larvae are of the chewing type; but in the great majority of species the body tapers gradually to the front end and terminates in a small conical segment which can be protruded or retracted. This head segment bears no eyes, and no true mouth parts. There is a pair of minute rudimentary sense organs and a pair of prominent mouth hooks which work vertically to tear the tissues upon which the larva feeds or into which it tunnels. The larvae typically have a complex pair of spiracles on the truncate last segment of the abdomen (Fig. 20.10,C), and, sometimes at least, another pair near the front end of the body; but commonly none along the sides of the body on the other abdominal segments. Such larvae are called *maggots*. They live mostly buried or hidden in decaying animal or vegetable matter, in water or mud, or inside the bodies of plants, insects, and other animals. There are strikingly few that feed externally upon plants and comparatively few crop pests of any kind. The most serious are certain gall flies, *e.g.*, the Hessian fly (page 531), the many fruit flies of the family Trypetidae (page 812), some leaf miners, root maggots, and borers in the stems of plants. The attacks of the larvae and adults upon animals are much more serious. This is the most dangerous order for the carrying of human and animal diseases (pages 28, 32). Many species suck the blood of animals as adults or live as larvae in their bodies. On the other hand, we must note the great benefit that accrues to us from the work of scavenger larvae and from those that are predaceous or



FIG. 6.98. A black fly, *Simulium* sp., female enlarged. (From Osborn, "Agricultural Entomology," after U.S.D.-A.)

parasitic on various insects. Genetic experiments (page 812).

The pupae of Diptera break through the body wall and can be removed by having a single pair of legs protected in a unique manner. The active larval instar, when retained about the pupa, is a large seed, and its walls are tight and watertight as a *puparium* (Figs. 2.15,D, and 2.15,E). *Orthorrhapha* spend the pupal stage in a particular protective covering.

A good many of the few groups in which a *boscidae* and the tsetse fly method of reproduction to which the term *pa* *Cecidomyiidae*.

It is easy to mistake the observer is not careful the presence of halteres. Hymenoptera, because they like the wasps, or dense are louse-like or tick-like by the number of legs which are exposed pierce

Small- to medium-sized with only one pair of wings with few veins. The head and abdomen very distended. Compound eyes sponging or piercing-sucking and metathorax fused with generally five-segmented. maggot-like with head grown by a pair of mouth hooks skeleton. Larval spiracles and a large group on large appendages; sometimes but often enclosed in a puparium.

Specialists are fairly numerous at least in its major aspects.

A SYNOPSIS

- A. Suborder *Orthorrhapha*. the pupal skin or puparium or a transverse split between. Pupa usually naked, sometimes have a small, lunate-shielded lunule. Larvae often with 1. *Nemocera*. The Long 39 similar segments.

eight families, Muscidae and there are many good whatever, ly being short it exclusively setting the eggs and laid.

s is complete rvae are well adults both abits and spe extreme degree y other order. ases where the together and ind of food, as g the beetles. legless and in order have no

2.15,C, and ies where the osquitoes, for 2,G, and 21.1), e larvae are of it in the great e body tapers t end and ter- l or retracted. s. There is a minent mouth the larva feeds



a. 6.98. A black fly, *Simulium* sp., male enlarged. from Osborn, "Agricultural Entomology," after U.S.D.-

ir bodies. On ies to us from predaceous or

parasitic on various insects and from the employment of *Drosophila* in genetic experiments (page 75).

The pupae of *Diptera* (Fig. 5.16,G,H) have the appendages free from the body wall and can be distinguished from the pupae of all other orders by having a single pair of wing pads. In the higher families the pupa is protected in a unique manner. Instead of shedding the skin of the last active larval instar, when the pupa is formed, this dried larval skin is retained about the pupa and serves as a cocoon. It is often inflated like a large seed, and its walls become very hard and thickened to form an airtight and watertight case. Such a case about a larva or pupa is called a *puparium* (Figs. 2.15,D, and 5.17,C). All flies of the suborder *Cyclorhapha* spend the pupal stage in a puparium; most of the suborder *Orthorrhapha* do not. In the latter group the pupa commonly has no particular protective covering; rarely a cocoon is formed.

A good many of the flies are ovoviviparous, and in this order we have a few groups in which a viviparous reproduction occurs, e.g., the Hippoboscidae and the tsetse flies of the family Muscidae. Another remarkable method of reproduction is the production of young by larvae and pupae, to which the term *paedogenesis* is applied. This occurs in certain Cecidomyiidae.

It is easy to mistake many of the flies for other kinds of insects. If the observer is not careful to note the number of wings and especially the presence of halteres, he will be likely to place many of his flies as Hymenoptera, because they are commonly banded with yellow and black, like the wasps, or densely covered with hairs like bees. A few species are louse-like or tick-like in form but can be distinguished from ticks by the number of legs and from lice by the nature of the mouth parts, which are exposed piercing organs (Figs. 20.22, 20.23).

Small- to medium-sized, soft-bodied insects. Adults mostly diurnal, with only one pair of wings, the front pair, which are narrow, membranous, with few veins. The hind wings are modified into halteres. Head, thorax and abdomen very distinct. Head vertical, very free-moving, subhemispherical. Compound eyes large; three ocelli usually present. Mouth parts sponging or piercing-sucking; labial palps always wanting. Prothorax and metathorax fused with the mesothorax, but scutellum distinct. Tarsi generally five-segmented. Metamorphosis complete. Larvae legless, usually maggot-like with head greatly reduced; the mouth parts in these cases replaced by a pair of mouth hooks articulating to an internal cephalopharyngeal skeleton. Larval spiracles generally restricted to a small pair on prothorax and a large group on last segment of abdomen. Pupa generally with free appendages; sometimes oblect in the Orthorrhapha; very rarely in a cocoon, but often enclosed in a puparium.

Specialists are fairly well agreed about the classification of the *Diptera*, at least in its major aspects.

A SYNOPSIS OF THE ORDER DIPTERA

A. Suborder *Orthorrhapha*. Straight-seamed Flies. The adult insects escape from the pupal skin or pupal case through a T-shaped or straight split down the back or a transverse split between the seventh and eighth segments of the abdomen. Pupa usually naked, sometimes in a cocoon, rarely in a puparium. Adults do not have a small, lunate-shaped sclerite above the antennae known as the frontal lunule. Larvae often with a distinct head.

1. *Nemocera*. The Long-horned Flies. Antennae usually long and slender, of 6 to 39 similar segments. Palps usually four- or five-segmented, generally pendu-

lous. Larvae have a distinct head, eyes, and true mandibles working transversely. First anal cell of wings almost never narrowed toward the wing margin. Discal cell generally absent. Mostly very slender flies.

- Family 1. Crane flies, Family Tipulidae (Fig. 6.97).
- Family 2. Moth flies and sand flies, Family Psychodidae.
- Family 3. Mosquitoes, Family Culicidae.
- Family 4. Midges, Family Chironomidae.
- Family 5. Gall gnats, Family Cecidomyiidae (Itonididae).
- Family 6. Fungus gnats, Family Mycetophilidae.
- Family 7. Buffalo gnats or black flies, Family Simuliidae (Fig. 6.98).

- 2. *Brachycera*. *The Short-horned Flies*. Antennae usually short, of three segments, last segment sometimes annulate or with a style in addition, like a small whip of withered segments at the end. Palps one- or two-segmented, porrect. Larvae often have the head reduced in size and invaginated, and mouth hooks working vertically, instead of mandibles. Discal cell usually present. First anal cell always closed or narrowed toward the wing margin.

- Family 8. Net-winged midges, Family Blepharoceridae.
- Family 9. Horse flies, Family Tabanidae.
- Family 10. Soldier flies, Family Stratiomyidae.
- Family 11. Snipe flies, Family Rhagionidae (Leptidae).
- Family 12. Robber flies, Family Asilidae (Fig. 6.102).
- Family 13. Bee flies, Family Bombyliidae (Fig. 6.103).
- Family 14. Long-legged flies, Family Dolichopodidae.

- B. Suborder *Cyclorrhapha*. Circular-seamed Flies. The adults escape from the pupal case through a split that runs round the end of the case and releases a circular lid that is pushed off or aside. Pupa always enclosed by the skin of the last active larval stage, which hardens to form a puparium. Adults with a frontal lunule and antennae generally of three segments, the third bearing an arista or style. Head of larvae always greatly reduced and invaginated into the pharynx. First anal cell always closed.

- 3. *Aschiza*. *Flies without a Frontal Suture*. Cap of puparium pushed off by expansion of the face of the adult, when it is ready to emerge; therefore there is no frontal lunule.

Family 15. Humpbacked flies, Family Phoridae.

Family 16. Flower flies or hover flies, Family Syrphidae (Fig. 2.15).

- 4. *Schizophora*. *Flies with a Frontal Suture*. A line or seam circles round above the base of the antennae and sometimes extends down nearly to the mouth on either side of the face. This is the vestige of a crack in the head through which a membranous, expansible, bladder-like structure, known as the *ptilinum*, is forced out when the adult is ready to emerge. By inflating the ptilinum with body fluids, the cap of the puparium is forced off. The bladder is then withdrawn into the head and is seen only if one catches the adult very shortly after its emergence.

- a. *Acalyptratae*. Flies with small *tegulae*, i.e., small, flat, membranous expansions connecting the base of the wing, behind, to the thorax. They do not have a complete transverse suture across near the middle of the thorax. They are all small flies, some very small. The eyes of males do not come together on top of the head.

Family 17. Thick-headed flies, Family Conopidae (Fig. 6.106).

Family 18. Ortalid flies, Family Ortalidae.

Family 19. Fruit flies, Family Trypetidae (Fig. 6.108).

Family 20. The frit fly and others, Family Chloropidae.

Family 21. Shore flies, Family Ephydriidae.

Family 22. The pomace fly and others, Family Drosophilidae.

- b. *Calyptratae*. Flies with well-developed *tegulae* or *squamae*, i.e., thin, sub-circular membranes just behind the base of the wing close against the thorax (Fig. 6.96). The thorax has a complete transverse suture near mid-length, above. This division includes our commonest and best-known flies. They are all medium to large in size. The males can often be distinguished

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tance, at the top o

Family 23. Anthomy

Family 24. House fly

Family 25. Flesh flies

Family 26. Tachina

Family 27. Bot flies,

- 5. *Pupipara*. Louse-like, segmented abdomen, a parasites on mammals develop viviparously u growth taking place at from special uterine gla

Family 28. The sheej

Family 29. Bee lice,

Family Tipulidae.¹ Crane extremely large mosquitoes, observance of crane flies. T abdomen cylindrical, the wing (Fig. 6.97). The wings are v the basal half of the wings are around the posterior margin mottled. These flies lack the of course they cannot bite. are nearly 2 inches long, while three times as long as the bod long. A good recognition ch that extends from the base of thorax, the point of the V dir clumsy flyers, found flying up meadows, forests, or damp pl eggs are most commonly thru larvae are very tough skinr fingers of varied design surrou So far as known, the adults h moist soil, muddy water, or the larvae cause appreciable often called meadow maggot.

Family Psychodidae.² M basement drains, and almost looking, velvety-winged, sho quently only $\frac{1}{16}$ inch) occu little moths than like flies. legs. The legs are short; the parallel long veins but with hairs. The larvae live in w organisms, or filth. In the t known as sand flies, have pi besides being carriers of cert

¹ ALEXANDER, C. P., "The 25, pp. 767-993, 1919; pt. II Conn. Geol. Natural History California," *Bul. So. Calif.* 1947.

² HASEMAN, L., "North / 299-333, 1907.

from the females, by having the eyes contiguous, at least for a short distance, at the top of the head.

Family 23. Anthomyid flies, Family Anthomyiidae.

Family 24. House fly family, Family Muscidae.

Family 25. Flesh flies, Family Sarcophagidae.

Family 26. Tachina flies, Family Tachinidae.

Family 27. Bot flies, Family Oestridae (Figs. 20.9 and 20.17).

5. *Pupipara*. Louse-like, often wingless flies, with a very tough skin, indistinctly segmented abdomen, and legs inserted far apart on the sternum. External parasites on mammals (including bats), on birds, or on insects. The larvae develop viviparously until full grown and are born shortly before pupation, all growth taking place at the expense of the mother fly, which nourishes the larva from special uterine glands (Fig. 20.22). Antennae one- or two-segmented.

Family 28. The sheep-tick and louse flies, Family Hippoboscidae (Fig. 20.22).

Family 29. Bee lice, Family Braulidae.

THE PRINCIPAL FAMILIES OF DIPTERA

Family Tipulidae.¹ Crane Flies or Daddy-long-legs. The tales sometimes told of extremely large mosquitoes, when not pure fabrication, may be founded on the observance of crane flies. Their shape is similar to that of mosquitoes—long, the abdomen cylindrical, the wings narrow, the antennae and legs very long and slender (Fig. 6.97). The wings are very narrow at the base, almost petiolate. The cells on the basal half of the wings are unusually long and slender, and the costal vein continues around the posterior margin of the wing. Many species have the wings spotted or mottled. These flies lack the scales on wing veins that characterize mosquitoes, and of course they cannot bite. Many of the species approach 1 inch in length. Some are nearly 2 inches long, while the smallest measure only $\frac{1}{8}$ inch. The legs are two or three times as long as the body and are very easily broken off. The halteres are very long. A good recognition character is an impressed linear mark, in the shape of a V, that extends from the base of one wing to the base of the other across the back of the thorax, the point of the V directed backward. Crane flies are the tan-colored, weak, clumsy flyers, found flying up and dropping into the grass as one walks through low meadows, forests, or damp places where there is an abundance of grass or weeds. The eggs are most commonly thrust into the soil. The cylindrical, brownish or olive-gray larvae are very tough skinned and have very poorly developed heads, and fleshy fingers of varied design surround the tail end. These may be protruded or withdrawn. So far as known, the adults have no economic importance. The larvae usually live in moist soil, muddy water, or decomposing material, rarely on foliage. Occasionally, the larvae cause appreciable injury by eating the roots of grass or corn. They are often called meadow maggots or leatherjackets (page 521).

Family Psychodidae.² Moth Flies and Sand Flies. Sometimes about sinks and basement drains, and almost always where there is sewage, small, extremely wooly-looking, velvety-winged, short, broad-bodied flies, not over $\frac{1}{8}$ or $\frac{1}{6}$ inch long (frequently only $\frac{1}{16}$ inch) occur in considerable numbers. They look much more like little moths than like flies. Their flight is soft and weak, but they are active on their legs. The legs are short; the wings broad and oval, rather evenly divided by 10 straight parallel long veins but with very few closed cells. The venation is obscured by the hairs. The larvae live in water or moist organic material, feeding on algae, micro-organisms, or filth. In the tropics and subtropics, species of the genus *Phlebotomus*, known as sand flies, have piercing-sucking mouth parts and are seriously annoying, besides being carriers of certain human diseases, such as Verruga in Peru, Papataci

¹ ALEXANDER, C. P., "The Crane-flies of New York," pt. I, *Cornell Univ. Memoir* 25, pp. 767-993, 1919; pt. II, 38, pp. 691-1133, 1920; "Crane-flies of Connecticut," *Conn. Geol. Natural History Surv. Bul.* 64, pt. 4, pp. 183-486, 1942; "Crane-flies of California," *Bul. So. Calif. Acad. Sci.*, 44:33-45, 1945; 45:1-16, 1946; and 46:35-50, 1947.

² HASEMAN, L., "North American Psychodidae," *Trans. Amer. Ento. Soc.*, 33: 299-333, 1907.

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fever in the Mediterranean area, and Leishmaniasis in Asia and South America (Table 1.2). The only other importance is as a nuisance about habitations of man.

Family Culicidae.¹ Mosquitoes. Mosquitoes, because of their aggressiveness toward man, are among the best known of all insects. They are delicate, fragile, soft-skinned, very slender flies (Fig. 21.3). The body is strongly humped, both head and abdomen drooping downward from the thorax, which is much deeper than wide, and lacks the V-shaped suture of the crane flies. The legs are two or three times as long as the body, the head small, the mouth parts long, stiff, and straight and in the female used for sucking blood (Fig. 4.7). The antennae are filiform, about as long as the beak, slender, with enlarged basal segment containing sound-receiving organs (page 120). In the male they are generally densely and long plumose. The body of a true mosquito probably never exceeds $\frac{1}{2}$ inch long, nor the wing spread $\frac{3}{4}$ inch, and the vast majority are at least one-third smaller than this. The complete fringe of large scales around the wing margin and along each of the veins gives the wings a peculiarly characteristic appearance. The costal vein encircles the wing as in Tipulidae. The mouth palps lie parallel with the beak, like an additional pair of antennae. The eyes are large, but there are no ocelli.

All mosquitoes develop in water. The eggs are usually laid singly in water or depressions where water may accumulate, but in *Culex* they are fastened together in a vertical position to form a raft. They generally float on the surface, and soon the larvae issue from the eggs into the water. The larvae of mosquitoes (Fig. 21.1) are the common "wigglers" of rain barrels and quiet pools. The head is large and has complex mouth brushes that, constantly in motion, waft food into the mouth. The mouth parts of the larvae are of the chewing type, and they feed on algae and other small plant or animal life either living or dead. The thorax is swollen and appears as one segment, but has no trace of legs in this stage. The abdomen is slender and bears on the eighth or next-to-last segment a short tube, known as a siphon, which the larva must thrust up into the air at intervals to breathe. This supply of air is supplemented by four finger-like tracheal gills attached to the last segment on the body, by which oxygen is taken from that dissolved in water. The gills alone will not keep the larvae alive, and they must come often to the surface to breathe. Indeed, they usually lie with the siphon projecting up through the surface film and the rest of the body hanging down at an angle in the water. In the larvae of anopheline mosquitoes, the siphon is very short and the larvae generally lie parallel to the surface just below the surface film. When disturbed, mosquito larvae swim down into the water by lashing the abdomen from side to side.

In as short a time as 2 days to 2 weeks, the larvae may be full-grown, about $\frac{3}{8}$ inch long in common species. The change to the pupal stage takes place quickly at the fourth molt. This is a very unusual kind of a pupa (Fig. 21.1). It swims about actively in the water, avoids enemies, and does nearly everything the larva does except feed. It breathes through two trumpet-like tubes on the thorax. The eyes, legs, and wings can be seen developing through the body wall on the large combined head and thorax. The pupal stage is often called a "tumbler." After a few hours to a few weeks in this condition, the insect splits its skin down the back and the adult crawls out, balances for a few moments on the empty pupal shell until its wings spread and dry, and then flies away. Most species pass through a number of generations each year.

No family of insects is of greater importance to man. The transmission of malaria, yellow fever, dengue, filariasis, and encephalitis (Table 1.2) constitutes a total injury against the human race that is unequaled by any other family of insects. In addition to the transmission of deadly disease organisms, the irritation, annoyance, and interference with work and pleasure caused by their bites and buzzing render mosquitoes

¹ HOWARD, L. O., H. G. DYAR, and F. KNAB, "The Mosquitoes of North and Central America and the West Indies," *Carnegie Institute of Washington, Publ.* 159, vols. I-IV, 1912-1917; MATHESON, R., "Mosquitoes of North America," Comstock, 1944; HORSFALL, W. R., "Mosquitoes: Their Bionomics and Relation to Disease," Ronald, 1955; FOOTE, R. H., and D. R. COOK, "Mosquitoes of Medical Importance," *U.S.D.A. Agr. Handbook* 152, 1959; CARPENTER, S. J., and W. LACASSE, "Mosquitoes of North America," Univ. California Press, 1955.

one of the greatest plagues of discussed on page 998.

Family Chironomidae.¹ M and habits the midges resemble family are very small, typical inch in length, and often minute not confined to the veins and to the posterior margin of the piercing. The veins on the behind. The antennae of the and the wings shorter and broad, pictured with white and black; these gnats dancing in the air group of minute midges are black which in many sections of America dusk and dawn during the summer usually laid in the water or in masses or strings by a gelatinous skin, with a distinct head. Most species develop in standing water, dredged from depths of surrounding material, inside of bloodworms because of their red color are green or transparent. Most are very important as food for fish and nuisances because of their annoying bites.

Family Cecidomyiidae.² (Als as in the midges and mosquitoes long slender legs, decumbent are broader and with fewer visible apparent cross-veins. The wings the hairs which cover the wing head is small; the antennae 1 segment. The antennae are whorls of hairs on the antennae microscopic terminally and much less never piercing-sucking, frequently exceeds $\frac{3}{8}$ inch. The biological interest surprising are gallmakers. A very common *strobiloides* (Fig. 1.6,D). Some 531), chrysanthemum gall on (page 742), and cloverseed midges forming galls. Some are sessile larvae have neither legs nor eyes the underside of the first thoracic plate, more or less forked in form known, but it is useful in recording increase their numbers in the pupae are either naked or pro-

¹ MALLOCH, J. R., "The Chironomidae," *Natural History*, vol. 10, art. 10, 1917; *Bul. N.Y. State Museum*, 1917; *Cornell Univ. Agr. Exp. Sta. Mem.* 1917; FELT, E. P., "Key to the Chironomidae," *Trans. Am. Ent. Soc.* 310 pp., 1917; "A Study of the Chironomidae," *Trans. Am. Ent. Soc.* 257, 1913-1925, and "Phylogeny of the Chironomidae," *Genera Insectorum*, vol. 10, 1917.

one of the greatest plagues of man. The life histories and control of mosquitoes are discussed on page 998.

Family Chironomidae.¹ Midges, Gnats, and Punkies. In general build (Fig. 21.5) and habits the midges resemble mosquitoes and crane flies, but the members of this family are very small, typical species being about $\frac{1}{10}$ inch long, rarely exceeding $\frac{3}{8}$ inch in length, and often minute. The wings are either bare or, if hairy, the hairs are not confined to the veins and wing margins. The costal vein does not continue around to the posterior margin of the wing, and the mouth parts are short, generally non-piercing. The veins on the anterior margin of the wing are thicker than the ones behind. The antennae of the males are very bushy. The body is generally stouter and the wings shorter and broader than in mosquitoes. In many species the wings are pictured with white and black spots and there are very few closed cells. Swarms of these gnats dancing in the air near swamps are often mistaken for mosquitoes. One group of minute midges are bloodsucking and include the "punkies" or "no-see-ums," which in many sections of American woods and mountains become almost intolerable at dusk and dawn during the summer, because of their hot painful bites. The eggs are usually laid in the water or moist decaying organic matter and are often held together in masses or strings by a gelatinous secretion. The larvae are cylindrical and thin-skinned, with a distinct head. Some of the pupae are active, like those of mosquitoes. Most species develop in standing water of either ponds, ditches, or lakes. Some have been dredged from depths of 1,000 feet in lakes. They often make tiny tubes of the surrounding material, inside which the larvae live. Some of the best known are called bloodworms because of their red color, which is due to hemoglobin in the blood. Others are green or transparent. Most of them are probably scavengers. They are rated as very important as food for fresh-water fishes, but the adults often become dreadful nuisances because of their attraction to light.

Family Cecidomyiidae² (Also Called Itonididae). Gall Gnats. In this family, also, as in the midges and mosquitoes, the body is slender, somewhat mosquito-like, with long slender legs, decumbent head, and filiform antennae (Fig. 18.16), but the wings are broader and with fewer veins, usually only three weak longitudinal veins and no apparent cross-veins. The wings are hairy, and the costal vein encircles the wing; the hairs which cover the wing membrane generally readily rub or wash off. The head is small; the antennae long, usually moniliform, with a whorl of hairs on each segment. The antennae are unique in possessing delicate looped threads among the whorls of hairs on the antennal segments. The abdomen of the female is often telescopic terminally and much elongated as an ovipositor. The mouth parts are short, never piercing-sucking, frequently not functional in the adults. The wing spread rarely exceeds $\frac{3}{8}$ inch. These frail gnats or midges have an importance to man and biological interest surprising for creatures so small and delicate. Most of the species are gallmakers. A very common example is the pine-cone willow gall, *Rhabdophaga strobiloides* (Fig. 1.6, D). Some very destructive species, such as the Hessian fly (page 531), chrysanthemum gall midge (page 877), wheat midge (page 525), pear midge (page 742), and cloverseed midge (page 570) feed on cultivated crops, sometimes not forming galls. Some are scavengers, and a few are predaceous or parasitic. The larvae have neither legs nor evident head. They usually possess, when full-grown, on the underside of the first thoracic segment, a unique, hard, chitinized, dark-colored plate, more or less forked in front, called the breastbone. Its function is not certainly known, but it is useful in recognizing the larvae of this family. Some of the species increase their numbers in the larval stage, a phenomenon called paedogenesis. The pupae are either naked or protected by a puparium or by a cocoon.

¹ MALLOCH, J. R., "The Chironomidae or Midges of Illinois," *Bul. Ill. State Lab. Natural History*, vol. 10, art. VI, pp. 275-543, 1915; JOHANSEN, O. A., "Chironomidae," *Bul. N.Y. State Museum* 86, pp. 76-316, 1905, and 124, pp. 264-85, 1908; CORNELL UNIV. AGR. EXP. STA. MEMOIR 205, 83 pp., 1937, and 210, 52 pp., 1937.

² FELT, E. P., "Key to American Insect Galls," *N.Y. State Museum Bul.* 200, 310 pp., 1917; "A Study of Gall Midges," *N.Y. State Museum Buls.* 165, 175, 180, 198, and 257, 1913-1925, and "Plant-galls and Gall-makers," Comstock, 1940; KIEFFER, J. J., *Genera Insectorum*, vol. 152, 1913.

Family Mycetophilidae.¹ Fungus Gnats. This is a large family of delicate, obscure, dull-colored flies of very little importance to man. They are of a general mosquito-like form, but have very long coxae, spurs at the end of the tibiae, two or three ocelli, and a short proboscis. The thorax is usually arched and the antennae long, without whirls of hairs. The wings have a moderate number of veins and fine tangled hairs on the membrane but no scales along the veins. Fungus gnats frequent dark, dank shelters such as basements, stables, and low-lying woods. The eggs are laid in fungi, decaying organic matter, or other damp, dark situations. The economic importance, which is slight, arises from injury to mushroom beds or to roots and planted seeds of crops. One species causes a kind of potato scab. The larvae are soft and whitish, with a small distinct head. Most species develop in wild fungi, especially mushrooms. Others that live in decaying wood, manure, rotting fruits, and vegetables possibly also feed on minute fungus growths. The most interesting thing about fungus gnats is the curious behavior of some gregarious larvae that

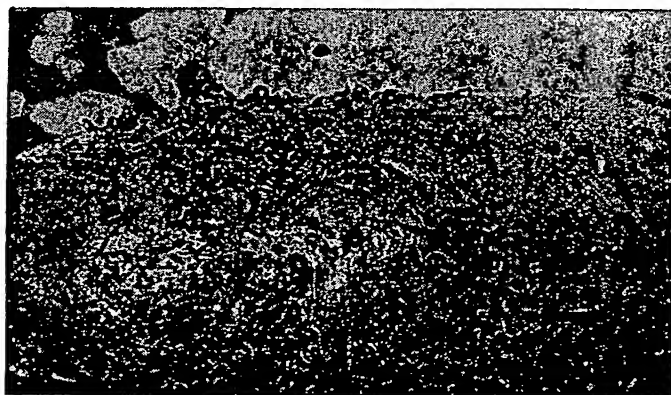


Fig. 6.99. Black fly larvae as they are found clinging to stones removed from the swift current of cold mountain streams. (Original.)

congregate in large masses several inches wide and 10 or more feet long, crawling over each other, two or three deep, and very slowly advancing.

Family Simuliidae.² Black Flies, Buffalo Gnats. Black flies are short, chunky, humpbacked flies (Fig. 6.98), not exceeding $\frac{1}{4}$ inch in length and more often about $\frac{1}{8}$ inch, with very broad, short wings, in which the anterior veins are stout, those behind very weak. There are no closed cells. The short, stout, horn-like antennae, composed of 11 closely compacted segments, scarcely exceed the width of the head. There are no ocelli. The legs are stout; the head large but set low against the arched thorax, giving the humpbacked appearance. The abdomen is short, stout, and thin-walled, so that it usually collapses badly in preserved specimens. The wings are free from hairs or scales, and the body has only slight pubescence. The females are among the most insatiable bloodsuckers and vicious of biting insects. Their life histories and control are described on page 1005. The eggs of black flies are fastened to the surface of stones, sticks, or vegetation that breaks the current of streams into ripples or rapids. The larvae (Figs. 5.15, G, and 6.99) lead a sporty life, clinging by means of sucker-like groups of minute hooks, one at each end of the body, to the surface of rocks in the swiftest parts of streams, the brinks of waterfalls, and other situations where the water is

¹ JOHANNSEN, O. A., "The Fungus Gnats of North America," *Maine Agr. Exp. Sta. Buls.* 172, 180, 196, 200, 1909-1912.

² DYAR, H. G., and R. C. SHANNON, "North American Two-winged Flies of the Family Simuliidae," *Proc. U.S. National Museum*, vol. 69, art. 10, pp. 1-54, 1927; MALLOCH, J. R., "American Black Flies or Buffalo Gnats," *U.S.D.A., Bur. Ento. Tech. Bul.* 26, 1914; METCALF, C. L., "Black Flies," *Bul. N.Y. State Museum* 289, 78 pp., 1932.

highly aerated. Clinging by the strainer-like mouth brushes into the mouth. Respiration through the anus. To anchor the pupae in fastened to the surface of the abdomen. Long, branching, fine hairs for tracheal respiration. The adults are on the wing before the pupae are hatched. Family Blepharoceridae.¹ Long-legged, mosquito- or midge-

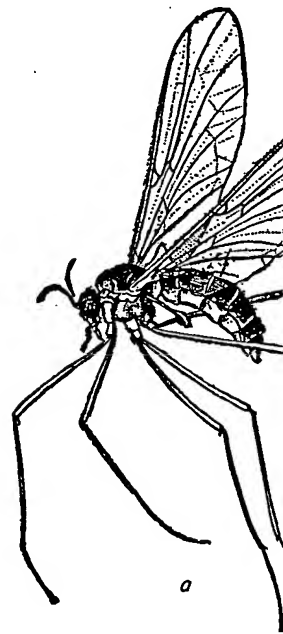
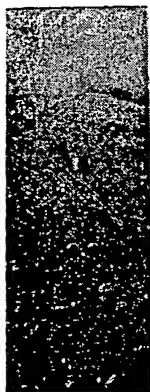


Fig. 6.100. Net-winged midges. a, natural size; b and c, upper- and lower-ventral views, respectively, of natural size. (From Sanderson and Co.)

from all others by the "fine spider web" crisscrossing the true veins. The pupal stage (Kellogg). There is a large space between the wing, and the anal margin around the end of the halteres. The mouth parts are long and may be two structurally different, one for sucking, the other feeding on nutritious material. The larvae and pupae are found in the same situations with black fly larvae and sticks in the swiftest current of streams. The segmented appearance (Fig. 6.10) is half the width of the others. They cling to the rock.

¹ KELLOGG, V. L., "The Net-winged Midges," *Sci., Zool.*, 3(3):187-226, 1903.

age family of delicate, They are of a general nd of the tibiae, two or rched and the antennae umber of veins and fine Fungus gnats frequent g woods. The eggs are uations. The economic n beds or to roots and o scab. The larvae are : develop in wild fungi, manure, rotting fruits, . The most interesting gregarious larvae that



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rica," *Maine Agr. Exp.*

Two-winged Flies of the art. 10, pp. 1-54, 1927; .S.D.A., *Bur. Ento. Tech. ate Museum* 289, 78 pp.,

highly aerated. Clinging by the tail the body sways freely in the water, and remarkable strainer-like mouth brushes sift minute organic matter from the water and force it into the mouth. Respiration is by means of short retractile gill filaments near the anus. To anchor the pupae in the swift current a slipper- or vase-shaped cocoon is fastened to the surface of the rock, and in this the pupa is fastened by hooks on its abdomen. Long, branching, finger-like tracheal gills attached to the thorax accomplish respiration. The adults emerge under water, float to the surface in a bubble of air, and are on the wing before the swift current can drown them.

Family Blepharoceridae.¹ Net-winged Midges. This family of moderate-sized, long-legged, mosquito- or midge-like gnats ($\frac{1}{4}$ to $\frac{1}{2}$ inch long) can be distinguished

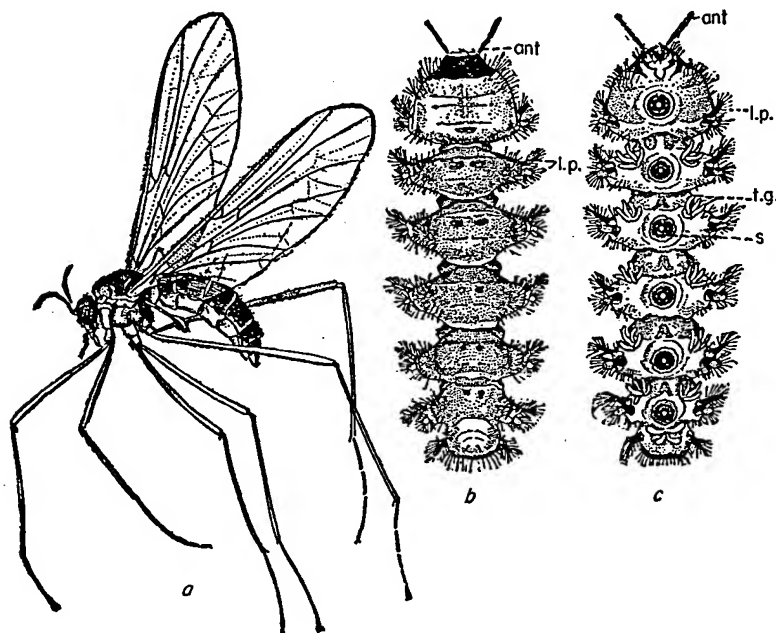


FIG. 6.100. Net-winged midges. a, The adult female of *Bibiocephala elegantulus*, $2\frac{1}{2}$ times natural size; b and c, upper- and undersides of the larva of *B. comstockii*, about 5 times natural size. (From Sanderson and Jackson, "Elementary Entomology," after Kellogg, Ginn & Co.)

from all others by the "fine spider-web-like network of lines" which traverses the wings, crisscrossing the true veins. These are creases left by the folding of the wings in the pupal stage (Kellogg). There is no closed discal or first-medial-2 cell near the middle of the wing, and the anal margin of the wing is remarkably excised or notched to fit around the end of the halteres. The eyes of both sexes touch on top of the head. The mouth parts are long and adapted for piercing. According to Comstock, there may be two structurally different kinds of females in the same species, one blood-sucking, the other feeding on nectar. The adults are much less noticed than their curious larvae. The larvae and pupae are common in swift mountain streams in the same situations with black fly larvae and pupae, that is, clinging to the surface of stones and sticks in the swiftest current. They attract attention because of their pronounced segmented appearance (Fig. 6.100). Alternating segments are constricted to less than half the width of the others. If one tries to pick them up, one is amazed at how tightly they cling to the rock. This is accomplished by a median ventral row of

¹ KELLOGG, V. L., "The Net-winged Midges of North America," *Proc. Calif. Acad. Sci., Zool.*, 3(3):187-226, 1903.

suckers. There are short tracheal gills for respiration. These curious larvae are said to eat algae and diatoms. The pupae are black. Their importance to man is apparently negligible.

Family Tabanidae.¹ Horseflies, Deerflies. This family includes the largest blood-sucking flies (Fig. 20.2). They range in size from about $\frac{1}{4}$ to 1 inch long. The body regions are closely compacted. They are very firm-bodied and hairy but not bristly flies, the hairs short and fine. They have strong legs and wings, the latter well provided with veins and often colored or pictured with bands and spots. The middle tibiae always have two spurs at the end. The costal vein encircles the entire wing margin. The head is large, a little wider than the thorax, short, concave behind. The eyes are often brilliantly colored during life with green, purple, or ruby, frequently in bands. The eyes cover nearly all the upper part of the head, but do not extend close to the mouth parts on the lower side of the head, being peculiarly cut away below. The thorax and abdomen are usually faintly spotted or banded. The antennae are shorter than the head, stiff, swollen at the base of the long third segment, and in the genus *Tabanus*, with a projecting spur on the upper side, like a thumb. The mouth parts are rather short and thick, piercing-sucking in the female, but not capable of penetrating flesh in the males, which feed on the nectar of flowers, honeydew, and other exposed sweets and are not found about animals. The mouth parts have also fleshy labella, as in the sponging mouth parts of the house fly. Horseflies are active in hot clear weather, though often most abundant in low woods along streams and about marshy lakes. They are very strong fliers, easily keeping up with a running horse or an automobile, and make a very loud hum. They bite all sorts of warm-blooded animals, including man; their life histories and economic importance are discussed on page 940. The eggs are typically laid upon leaves or stems of water plants that project above the surface of the water, often in wedge-shaped masses. The larvae tunnel through moist soil or swim in the water, devouring small animal life that they

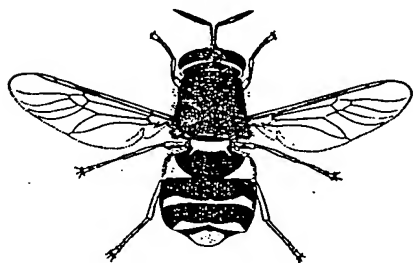


FIG. 6.101. A stratiomyid or soldier fly, *Stratiomya potamida*, female. About twice natural size. (From Verrall, "British Flies.")

encounter. They are whitish, sometimes ringed with black, taper to both ends, and have elevated rings about the body on the principal segments. The head is small, the skin extremely tough. They respire through terminal posterior spiracles.

Family Stratiomyidae.² Soldier Flies. These are rather large to rather small flies, usually brightly marked, bare of bristles, and not very strong fliers. The antennae have three segments, the third segment with either a terminal style or a dorsal arista or ringed so as to suggest additional segments. The antennae are often carried in the form of a Y, the stem formed by the approximated, very slender, long, first segments of both

antennae (Fig. 6.101). The mouth parts are short, of the sponging type, the face generally retreating. The tibiae are without spurs at the end. The scutellum is often ornamented with spines or projections on its margin. The abdomen is often characteristically broad and flattened, but sometimes long. Thorax and abdomen are

¹ HINE, J. S., "Tabanidae of Ohio," *Ohio Acad. Sci. Spcl. Paper* 5, 63 pp., 1903, and "Tabanidae of the Western United States and Canada," *Ohio Naturalist*, 5: 217-248, 1904; STONE, A., "Bionomics of Tabanidae," *Ann. Ento. Soc. Amer.*, 23: 261-304, 1930, and "Nearctic Tabaninae," *U.S.D.A. Misc. Publ.* 305, 171 pp., 1938; PHILLIP, C. B., "Catalogue of Nearctic Tabanidae," *Amer. Midland Naturalist*, 37: 257-324, 1947, and 43: 430-437, 1950.

² JOHNSON, C. W., "Stratiomyia and Odontomyia of North America," *Trans. Amer. Ento. Soc.*, 22: 227-278, 1895; JAMES, M. T., "Stratiomyiidae," *Jour. Kans. Ento. Soc.*, 9: 33-48, 1935; JOHANSEN, O. A., "Stratiomyia Larvae and Pupae," *Jour. N.Y. Ento. Soc.*, 30: 141-153, 1928.

typically brightly banded margins, but sometimes a. The wings are rather sma rotund, not much longer t or faint behind; the squa do not hover before the. The eggs are laid in deca. Some of the larvae are pre usually flattened. The h tubular, breathing organ takes place in the last larv

Family Rhagionidae¹ (A ble, weak-skinned, sluggis mens, without bristles, bu species suggest small robb veins normally distributed legs are long, the tibiae, at the face usually retreating style, and usually very sh banded with half a dozen yellow hairs or by the gro long. Adults of certain sp and their own dead bodies masses as big as a football cusses the habit of the collected them by bushe them for food. The lar species live in the water rotting wood. A few spe traps, like the ant-lions insects caught. All are s predaceous. The family nomic importance. Som blood, but are not often e

Family Asilidae. Robbe ber flies are moderate-size often slender-bodied, but resembling bumblebees, ve hairy, and often humped (6.102). They got their from their ferocious mann from the air upon their pr sists of all sorts of insects. thorax by a slender neck, the eyes on top. Ocelli ar minal style or an arista. not very long. The abdo than the wings. The legs wings well provided with adults are found in open sur ing prey they fly but a shor vailing colors are gray, brov pile. The larvae of robber organic matter, under surfa insect larvae, especially b puparium, are very spiny.

¹ LEONARD, M. D., "Rh. Amer. Ento. Soc. Memoir 7.

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typically brightly banded with yellow and pale green especially developed on the margins, but sometimes uniformly yellow, black, or brilliant metallic green or blue. The wings are rather small, laid over each other at rest; the discal cell generally subrotund, not much longer than wide; the veins of the wing close together in front, sparse or faint behind; the squamae very small. The adults are common about flowers but do not hover before them as the syrphid flies do. They favor low wet situations. The eggs are laid in decaying, sappy wood, on or near water, on the soil, or in dung. Some of the larvae are predaceous, others are scavengers. They are very thick-skinned, usually flattened. The head is small, the tail end often tapered, sometimes forming a tubular, breathing organ with a chambered concavity or cleft at the end. Pupation takes place in the last larval skin. No important economic relation to man is known.

Family Rhagionidae¹ (Also Called Leptidae). Snipe Flies. These are rather variable, weak-skinned, sluggish flies of moderate to large size, with long tapering abdomens, without bristles, but often densely covered with fine short silky hairs. Many species suggest small robber flies in appearance. The wings are ample, with the wing veins normally distributed, the squamae very small or wanting, halteres large. The legs are long, the tibiae, at least the hind pair, with terminal spurs. The head is large, the face usually retreating. The antennae are three-segmented, with an arista or a style, and usually very short, sometimes long. The tapering abdomen is frequently banded with half a dozen white or yellow crossbands, formed either by close-set silky yellow hairs or by the ground color. Our common species range from $\frac{1}{2}$ to $\frac{3}{4}$ inch long. Adults of certain species are gregarious at egg-laying time and pile up their eggs and their own dead bodies on certain branches of trees or on rocks to form enormous masses as big as a football. Aldrich discusses the habit of the Indians, who collected them by bushels and cooked them for food. The larvae of varied species live in the water or in soil or rotting wood. A few species make sand traps, like the ant-lions, and eat the insects caught. All are supposed to be predaceous. The family has little economic importance. Some adults suck blood, but are not often encountered.

Family Asilidae. Robber Flies. Robber flies are moderate-sized to very large, often slender-bodied, but sometimes resembling bumblebees, very bristly or hairy, and often humped-bodied (Fig. 6.102). They got their common name from their ferocious manner of pouncing from the air upon their prey, which consists of all sorts of insects. The head is broad and short and well separated from the thorax by a slender neck, the front characteristically excavated or depressed between the eyes on top. Ocelli are present, the antennae three-segmented, with either a terminal style or an arista. The mouth parts are piercing-sucking, pointed, and stiff, but not very long. The abdomen is most often slender, tapering backward, often longer than the wings. The legs are very stout, long, and bristly, the squamae small, the wings well provided with veins, frequently stained brownish but not pictured. The adults are found in open sunny fields such as stubble fields. When disturbed or attacking prey they fly but a short distance, with a loud buzzing, before alighting. The prevailing colors are gray, brown, or black, but a few are marked with red or golden-yellow pile. The larvae of robber flies are also predaceous. They are found among decaying organic matter, under surface litter, in rotting wood, or in soil where they attack other insect larvae, especially beetle grubs. The pupae, which are not enclosed in a puparium, are very spiny.

¹ LEONARD, M. D., "Rhagionidae (Leptidae) in the United States and Canada," Amer. Ento. Soc. Memoir 7, pp. 1-181, 1930.

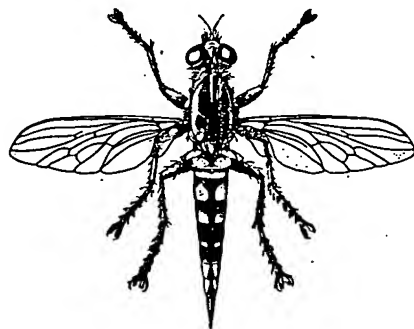


FIG. 6.102. A robber fly, *Erax maculatus*, female. About 2 times natural size. (From Ill. State. Natural History Surv.)

Family Bombyliidae.¹ Bee Flies. The common name, bee flies, is not very distinctive, since many other flies (Syrphidae, Asilidae) have also developed a protective mimicry of their stinging cousins, the bees and wasps. These medium-sized, elusive, handsome flies hover before flowers or stand still in the air or dart swiftly from spot to spot. Their bodies (Fig. 6.103) are usually very light, soft-walled, commonly densely covered with hairs but not usually bristly. The head is tucked close against the thorax, round, nearly covered by the compound eyes. The antennae are usually simply three-segmented, without arista or style, of variable length. Ocelli are present, mouth parts long or short, often very long and slender, adapted for securing nectar and pollen. Head, thorax, and abdomen are usually successively broader, rarely the abdomen slender, thread-waisted, but usually very short. The legs are not very stout, the squamae small. The wings are well traversed by veins, very often beautifully spotted or patterned. The colors are mostly black or dark brown, the wing markings the same, and the body covered with fine long yellowish, brownish, or white hairs, like a halo. While a few species are less than $\frac{1}{8}$ inch long, the average is around $\frac{1}{2}$ to $\frac{3}{4}$ inch long and the wing expanse $\frac{3}{4}$ to $1\frac{1}{2}$ inches. The larvae which are known are predaceous or parasitic on bee or wasp larvae, cutworms, or the eggs of grasshoppers. They have very small heads. They have a complex hypermetamorphosis. The pupa is not enclosed. Their economic value is not great since some attack other parasites and tend to offset the good done by destroying crop pests.

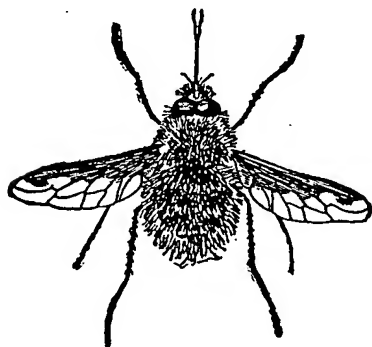


FIG. 6.103. A bee fly, *Bombylius major*. Twice natural size. (From Kellogg, "American Insects.")

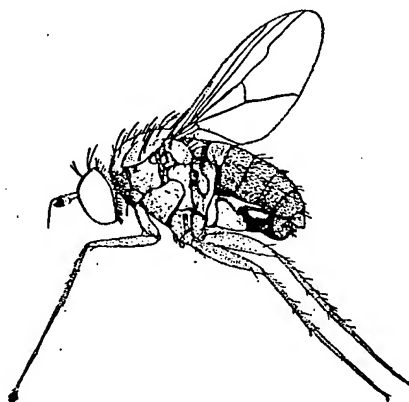


FIG. 6.104. A long-legged fly of the family Dolichopodidae, male. About 3 times natural size. (From Woodworth.)

Family Dolichopodidae.² Long-legged Flies. Small ($\frac{1}{8}$ to $\frac{1}{2}$ inch), slender, usually shining green, sometimes blue or yellow, nearly bare but somewhat bristly flies, with the discal (first medial 2) and second basal (medial) cells united, forming a very long cell lengthwise through the middle of the wing (Fig. 6.104). All but one of the large cells are open to the wing margin. The wings are large, sometimes patterned. The mouth parts are short and fleshy, used to envelop small soft-bodied flies and extract their body fluids or to draw nectar. The antennae are placed rather high on the front, not long, with two short and a third long segment, the latter with a dorsal arista or terminal style, which is frequently prominent. The face is not prominent. The abdomen is slender, tapering to the apex, legs sometimes rather long, usually bristly, provided in some males with greatly enlarged ornamental tarsi. The genitalia of the males are often conspicuously large. The adults are often found running over leaves or grass in moist habitats. The larvae, so far as known, are either scavengers or

¹ PAINTER, R. H., "Bombyliidae," *Trans. Kans. Acad. Sci.*, 42:267-301, 1939.

² ALDRICH, J. M., "North American Dolichopodidae," *Trans. Amer. Ento. Soc.*, 30:269-286, 1904; VAN DUZEE, M. C., F. R. COLE, and J. M. ALDRICH, "Dolichopus in North America," *Bul. U.S. National Museum* 116; 304 pp., 1921.

predaceous, and they live in far as known, are generally The economic importance

Family Phoridae.¹ Hump-backed Flies. The antennae is so much large segmented, with a long stem inch long in common species scattered, large bristles. When wings are present, they terminate before the tip of the abdomen and not forming any closed on the basal half. The eye is of the spongy type. The wings drooping behind, to give them ample and often adapted obscurely colored, are of the been found to dwell in the vegetable matter, fungi, they formed inside the larval skin.

Family Syrphidae.² Flower Flies. Flies in form and color, a very large types, some resembling wasps at the base of the abdomen, and a few like bees. The prevailing color is upon a ground color of polka dots may be found in bright sunlight. The adults feed. They are hovering in the air, with their wings of the body. They are mostly $\frac{1}{2}$ to 1 inch long, although some are all other flies by the presence of a thickening of the wing called the radiomedial cross-vein usually projecting at the base, short, with an arista on the head, usually not elsewhere. The importance of the family is shown by many species, especially aphids and other small soft-bodied insects. Other species are scavengers of ants, bees, wasps, or termites of trees. The bulb fly (parasitic on narcissus, amaryllis, and other flowers) and larvae of *Eristalis*, *Helophilus*, and *Helophorus* feed on other filthy liquids. The larvae of ants' nests, are curious scavengers of new Mollusca. The pupal skin and is to be found in many places have been recorded as occurring.

¹ BRUES, C. T., "North American Phoridae," 1903; MALLOCH, J. R., "Phoridae," 43:411-529, 1913.

² WILLISTON, S. W., "Syrphidae," *Bul.* 31, pp. xxx and 33; *Survey Bul.* 1, 1913, and *Bul.* 263, 1917; CURRAN, "Syrphidae," *Natural History* 78, pp. 24-25; *Univ. Ill. Bul.* 36, 142 pp.

predaceous, and they live in soil, decaying vegetation, or in the water. The pupae, so far as known, are generally unenclosed and have long breathing horns on the thorax. The economic importance of the family is nearly negligible.

Family Phoridae.¹ Humpbacked Flies. In these flies the third segment of the antennae is so much larger than the others that the antennae appear to be one-segmented, with a long stout bristle or arista. The body is rather short ($\frac{1}{20}$ to $\frac{1}{16}$ inch long in common species); the head and thorax are frequently provided with scattered, large bristles. The wings are often wanting, especially in the females. When wings are present, the two veins near the front of the wing are very heavy and terminate before the tip of the wing; the remaining veins are finer, running diagonally, and not forming any closed cells. The costal margin of the wings is often very bristly on the basal half. The eyes are small, the ocelli usually present. Mouth parts are of the sponging type. The thorax is arched, and the abdomen short, narrowed, and drooping behind, to give the flies a strongly humpbacked appearance. The legs are ample and often adapted for jumping. These flies, although small to minute and obscurely colored, are of the most remarkable habits of all the insects. A number have been found to dwell in the nests of ants, bees, and wasps. Others live in decaying vegetable matter, fungi, the carcasses of animals, or decaying insects. The pupa is formed inside the larval skin and breathes through a pair of long horns.

Family Syrphidae.² Flower Flies, Hover Flies, Syrphids. Although very diverse in form and color, a very large number of the species of flower flies fall into two general types, some resembling wasps, with bare, slender bodies, often slender-waisted at the base of the abdomen, and another lot being broad, very hairy, and mimicking bumblebees. The prevailing colors are yellow spots or crossbands or fasciae of yellow hairs upon a ground color of polished black or metallic blue, green, or violet. Most species may be found in bright sunshine about flowers, upon the nectar and pollen of which the adults feed. They are expert on the wing, flying with extreme swiftness or hovering in the air, with their wings fanning like a haze, but without any visible movement of the body. They are medium to large-sized, hard-bodied, very vigorous flies, mostly $\frac{1}{2}$ to 1 inch long, although a few are only $\frac{1}{8}$ inch. They may be distinguished from all other flies by the presence of a false or spurious vein (Fig. 6.96), which is a vein-like thickening of the wing between radius 4 and 5 and media 1 and 2 and bisecting the radiomedial cross-vein. The head is at least as broad as the thorax, the face usually projecting at the middle or next the mouth; antennae variable, generally short, with an arista on the third segment. There are no large bristles on the head and usually not elsewhere. The adults are important pollinizers, but the economic importance of the family arises largely from the predaceous habits of the larvae of many species, especially *Syrphus*, *Sphaerophoria*, and *Allograpta*. These feed on aphids and other small soft-bodied insects (page 66 and Fig. 2.15, C). The larvae of other species are scavengers in all kinds of decaying organic matter, or live in the nests of ants, bees, wasps, or termites, or are pests feeding in bulbs, fungi, cacti, or the trunks of trees. The bulb fly (page 880) and the lesser bulb fly (page 881) are serious pests of narcissus, amaryllis, and onions, in many parts of the United States. The rattailed larvae of *Eristalis*, *Helophilus*, and other genera (Fig. 6.105) have a very remarkable posterior telescopic tube for conducting air down to the larva as it feeds in sewage and other filthy liquids. The larvae of *Microdon* (Fig. 6.105), which are often found in ants' nests, are curious slug-like things that zoologists have several times described as new Mollusca. The pupal stage is always protected in a puparium formed of the larval skin and is to be found on either plants or the soil or in filth. Several species have been recorded as occasional intestinal parasites of man.

¹ BRUES, C. T., "North American Phoridae," *Trans. Amer. Ento. Soc.*, 29:331-404, 1903; MALLOCH, J. R., "Phoridae of the United States," *Proc. U.S. National Museum*, 43:411-529, 1913.

² WILLISTON, S. W., "Synopsis of North American Syrphidae," *U.S. National Museum Bul.* 31, pp. xxx and 335, 1886; METCALF, C. L., "Syrphidae of Ohio," *Ohio Biol. Survey Bul.* 1, 1913, and "Syrphidae of Maine," *Maine Agr. Exp. Sta. Bul.* 253, 1916, and 263, 1917; CURRAN, C. H., "Syrphidae of North America," *Bul. Amer. Museum Natural History* 78, pp. 243-304, 1941; HEISS, E. M., "Syrphidae, Larvae and Pupae," *Univ. Ill. Bul.* 36, 142 pp., 1933.

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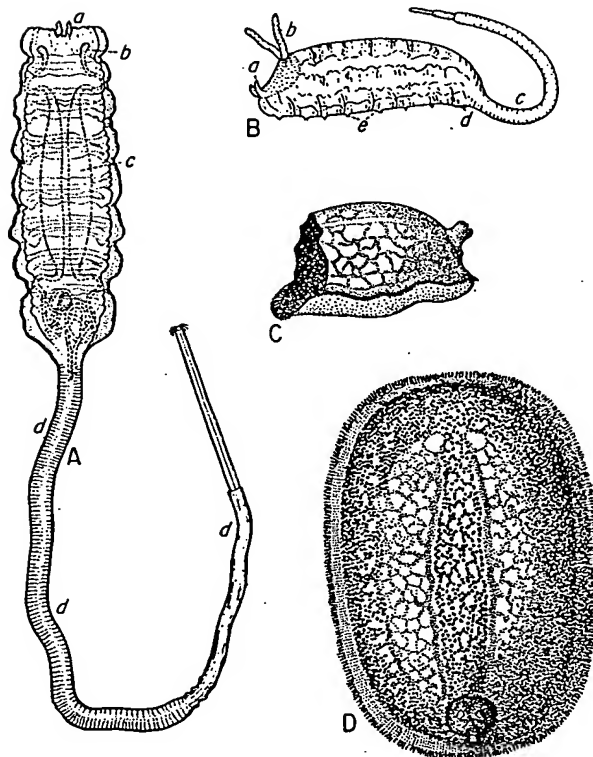


FIG. 6.105. Two curious larvae of Syrphidae or flower flies. A, the rattailed maggot of *Eristalis*, showing long extensile breathing tube at *d*; B, puparium of the same showing at *b* the cornua through which the pupa breathes; C, the empty puparium of *Microdon* from which the adult has escaped; D, the larva of *Microdon*, dorsal view. All enlarged 5 to 10 times. (From Metcalf, *Ohio Biol. Surv.*)

Family Conopidae.¹ Thick-headed Flies. These are medium-sized ($\frac{1}{4}$ to 1 inch long), slender-bodied, very firm-skinned flies (Fig. 6.106), frequently with the basal part of the abdomen slender and the apex downbent and swollen by the large genitalia in the male or extended into a long ovipositor in the female. Their build and yellowish-color markings often strikingly suggest wasps, but they are not so powerful in flight.



FIG. 6.106. A thick-headed fly, *Physocephala affinis*. Enlarged $\frac{1}{2}$. (From Kellogg, "American Insects.")

They are never very hairy, often bare. The eyes are well separated on top of the head in both sexes; the antennae average about as long as the head and are provided with either a terminal style or a dorsal arista. The head is often produced downward far below the eyes. The mouth parts are very long, sometimes as long as the entire body, slender, rigid, often sharply elbowed about mid-length. They are not used for piercing, however, since the adults, so far as known, feed on flowers. The wings are normally veined, sometimes patterned with brown, the cubital cell often unusually long. The adults lay their eggs on the bodies of

¹ VAN DUZEE, M. C., "Conopidae of North America," *Proc. Calif. Acad. Sci.*, 16:573-604, 1927; PARSONS, C. T., "Conopidae of North America," *Ann. Ento. Soc. Amer.*, 41:223-246, 1948.

wasps, bees, and grasshoppers, so in flight. The larvae are into posterior spiracles to a large tr The pupal stage is spent within of much importance to man.

Family Ortalidae. Ortalid F beautifully pictured with blackis



FIG. 6.107. An ortalid fly, *Pyrgocera undata*. About 3 times natural size. (F

The Trypetidae have the tip of the abdomen at a sharp angle. In the Ortalidae the tip of the abdomen is at an acute angle. The mouth opening on the lower side of the head is large, the mouth parts spongy. The venation of the wings is simple. The veins of the wings are close together but do not meet at the tip. This is a family of medium-sized flies, $\frac{1}{4}$ to $\frac{1}{2}$ inch long. Not enough is yet known about this family to estimate their numbers. The larva of the large wasp-like fly, *Pyrgocera undata* (Fig. 6.107), is a parasite of beetles. The adult fly lays her eggs on the wings of May beetles when they are new.

Family Trypetidae.¹ Frustrated flies, resembling the Ortalidae but distinguished by the difference in the shape of the mouth parts and the pattern of spots and more complex than

¹ BATES, M., "American Trypetid Flies," *U.S.D.A. Technical Bulletin*, 1907; PARSONS, C. T., "Conopidae of North America," *Ann. Ento. Soc. Amer.*, 41:223-246, 1948.

wasps, bees, and grasshoppers, sometimes accomplishing this feat while both insects are in flight. The larvae are internal parasites in such insects. They appose their posterior spiracles to a large trachea inside the host insect, presumably to secure air. The pupal stage is spent within the body of the host. The family is neither large nor of much importance to man.

Family Ortalidae. Ortalid Flies. This is one of two families that have the wings beautifully pictured with blackish spots or bands; the other family is called Trypetidae.

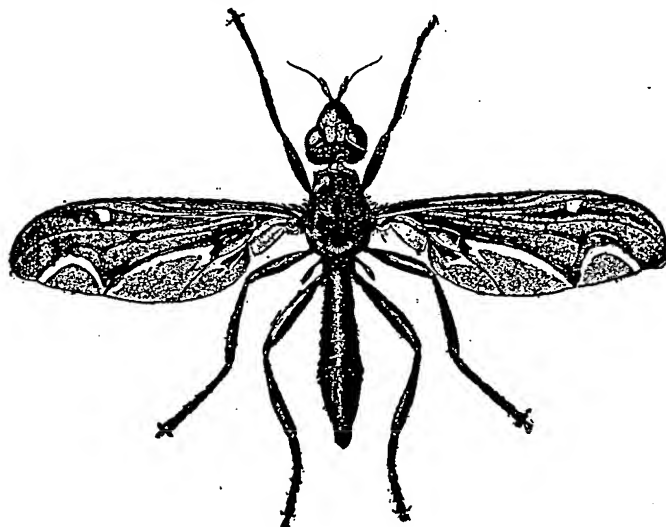


FIG. 6.107. An ortalid fly, *Pyrgota undata*, the larva of which is a parasite on June beetles. About 3 times natural size. (From Ill. State Natural History Surv.)

The Trypetidae have the tip of the subcostal vein imperfect, faint, or broken or bent at a sharp angle. In the Ortalidae it is sharp, clear, and normal, meeting the costal margin at an acute angle. There are no prominent bristles ("vibrissae") just above the mouth opening on the lower edge of the face in the ortalids. The head is rather large, the mouth parts sponging in type. The legs are usually stout with spurs at the apex of the middle tibiae only. The venation of the wings is simple; the subcosta and radius are close together but separate and distinct full-length. This is a rather large family of medium-sized flies, $\frac{1}{4}$ to $\frac{1}{2}$ inch long. Not enough is yet known about the larval habits in this family to estimate their importance to man. The larva of the large wasp-like species, *Pyrgota undata* (Fig. 6.107), is a parasite of adult May beetles. The adult fly lays her eggs beneath the wings of May beetles when they are in flight at night.

Family Trypetidae.¹ Fruit Flies. Superficially resembling the Ortalidae, these flies may be distinguished by the differences in wing venation described under that family (Fig. 6.108). The wing markings are in general of finer spots and more complex than in the Ortalidae; the colors are often beautifully intricate,



FIG. 6.108. A trypetid fly, the white-banded cherry fruit fly, *Rhagoletis cingulata*, female. Enlarged. (From Lockhead, "Economic Entomology," after Caesar.)

¹ BATES, M., "American Trypetidae," *Psyche*, 40:48-56, 1933; BENJAMIN, F. H., "Trypetid Flies," *U.S.D.A. Tech. Bul.* 401, 95 pp., 1934; PHILLIPS, V. T., "Trypetidae of North America," *Jour. N.Y. Ento. Soc.*, 31:119-154, 1923, and "Trypetid Larvae," *Memoir Amer. Ento. Soc.* 12, 161 pp., 1946.

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mostly pale brown, the spotting confined to the wings, the body itself usually plain. The venation is normal except for the characteristic degeneration of the apex of the subcostal vein. The first anal cell is sometimes prolonged into an acute extension at the distal angle. Vibrissae (large hairs of the upper "lip") are wanting. A row of bristly hairs margins the eyes at the upper front corner. The antennae are short, and the eyes rather small, not meeting above in either sex. The eggs of these flies are usually inserted into the tissues of plants. The larvae of some species bore in the stems of plants; some produce galls, some mine in leaves, and most important of all are those which bore into the flesh of fruits and vegetables. The latter include some of the most important of all economic insects: the apple maggot (page 732), the cherry fruit flies (page 769), the walnut husk fly (page 812), the Mexican fruit fly (page 812), the Mediterranean fruit fly (page 812), the oriental fruit fly (page 812), the melon fly (page 812), the olive fruit fly, *Dacus oleae*, and the currant fruit fly, *Epochra canadensis*.

Family Chloropidae¹ (Also Called Oscinidae). Frit Flies, Grass Stem Maggots, and Eye Gnats. These are small ($\frac{1}{16}$ to $\frac{3}{16}$ inch long), short-winged, bare flies, abounding in rank vegetation. Like the Ephydriidae, the wings are devoid of closed cells except close to the base, the anal cell being absent and the medial not separated from first medial 2. The subcostal vein is also wanting. They may be distinguished from the ephydriids by their small mouths, the short antennae with rounded third segment and bare arista, the occasional presence of vibrissae, the broad front and retreating face, and by the fact that they are not usually entirely black but are generally yellow-spotted or banded. The larvae of many species are phytophagous and include a number of very destructive pests such as the frit fly, *Oscinella frit*, and the gout fly, *Chlorops taeniopus*, which are pests of cereals in Europe. The wheat stem maggot (page 540) mines in the upper part of wheat stems, causing blighted heads. The larvae of *Hippelates* breed in decaying vegetation, and the adults are the vexatious eye gnats (page 1035), which are vectors of acute conjunctivitis.

Family Ephydriidae.² Shore Flies. These flies are similar structurally to the Drosophilidae, and especially to the Chloropidae, from which their uniform dark-brown or black color, without light markings, the frequent pubescence of the arista, the extremely large mouth, the entire absence of vibrissae, and usually swollen, convex face will help to separate them. The entire underside of the head forms a great mouth cavity. As in the Drosophilidae, there are two microscopic "breaks" in the costal vein on its basal half. These flies are commonly $\frac{1}{16}$ to $\frac{3}{8}$ inch long. A number of species of the genus *Ephydra* abound about salt, briny, or alkaline water, in which the larvae live and from which the pupae are frequently washed ashore to form great windrows. On account of their abundance, these have been collected, dried, and used as food by the Indians of the Southwest. The larvae are sometimes rattailed, like certain Syrphidae, but the tail in this case is forked or split toward the end. One remarkable species, called the petroleum fly, *Psilopa petrolei*, lives as larvae in pools of crude oil feeding upon other insects trapped in the oil. These larvae are about $\frac{1}{2}$ inch long, when full-grown.

Family Drosophilidae.³ The Pomace or Fruit Fly and Others. These are small, somewhat bristly flies, commonly $\frac{1}{16}$ to $\frac{1}{4}$ inch long, and of obscure coloration. The frons and face are broad. The face is nearly straight down below the antennae with prominent bristles (vibrissae) usually present at its lower margin. There are long, stout bristles on the upper part of the head. The arista is usually plumose. The abdomen is generally short and rather soft-walled. The wings are broad, with comparatively few veins and closed cells, the venation much as in the Ephydriidae. The subcostal vein is degenerate, incomplete, or entirely wanting, and the costal vein has

¹ MALLOCH, J. R., "Genera of Chloropidae of North America," *Can. Ento.*, 46:113, 1914; SABROSKY, C., "Chloropidae of Kansas," *Trans. Amer. Ento. Soc.*, 61:207-268, 1935.

² JONES, B. J., "Catalogue of Ephydriidae," *Univ. Calif. Publ. Ento.*, 1:153-98, 1906.

³ STURTEVANT, A. H., "The North American Species of Drosophila," *Carnegie Institution of Washington, Publ.* 301, 150 pp., 1921, and *Univ. Texas Publ.* 4213, 51 pp., 1942; PATTERSON, J. T., "Drosophilidae of Southwest," *Univ. Texas Publ.* 4313, pp. 7-216, 1943.

two distinct interruptions are found among grass a decaying fruits, apparent family is chiefly known from *sophila melanogaster* (Fig. have been most intensive inheritance has been determined studies of this ins little fly.

Family Anthomyiidae. Flies. These are soft-grayish to blackish, horse (Fig. 14.42) of moderate size (long) and of much the same as the house fly. Vein *me* straight or nearly so, a radial 5 cell is always wide of the male usually touch head; and the tegulae are is usually obscurely spotted white or grayish pollen. The abdomen is rather short tapering to a pointed tip are short, appressed into on the face, the arista vary to entirely bare. The face prominent, provided with is a large family, the larva tendency to feed upon decaying matter from which a number have adopted the habit of roots of vegetables. The (page 670), the onion maggot, the seed-corn maggot (page 540), the spinach leaf miner (page 540) are destructive, because of the place where the larvae live.

Family Muscidae⁴ (Inc known and most important) (page 1031), which is fairly weak-skinned, not very broad wings, in which the body by the forward-bent median grayish or brownish polliniferous.

¹ MORGAN, T. H., C. B. "ila," *Bibliographia Genet. Drosophila*, 632 pp., WILSON, L. V. MORGAN, and others, *simulans* and *Drosophila*, 1929.

² JOHANNSEN, O. A., "Amer. Soc.", 42:385-98, 1916; MORGAN, L. V., *Amer. Ento. Soc.*, 46:133-134, 1916.

³ HOUGH, G. DE N., "Science", 1899; SHANNON, R. C., 67-81, 1924; HEWITT, C. "Bionomics and Economy of fly," Comstock, 1951.

two distinct interruptions in its basal half as though it had been broken. These flies are found among grass and weeds and about all kinds of overripe, fermenting, or decaying fruits, apparently being attracted chiefly by acetic acid (Barrows). The family is chiefly known from its very common representative, the banana fly, *Drosophila melanogaster* (Fig. 6.109), whose structure, habits, and especially its genetics have been most intensively studied.¹ A very large part of what we know about inheritance has been determined by laboratory studies of this insignificant-looking little fly.

Family Anthomyiidae.² Root Maggot Flies. These are soft-skinned, bristly, grayish to blackish, homely-looking flies (Fig. 14.42) of moderate size ($\frac{1}{4}$ to $\frac{3}{8}$ inch long) and of much the same general build as the house fly. Vein *medius* 1 and 2 is straight or nearly so, and consequently *radial* 5 cell is always widely open; the eyes of the male usually touch on top of the head; and the tegulae are large. The body is usually obscurely spotted or striped with white or grayish pollen, rarely shining. The abdomen is rather short, broad at base, tapering to a pointed tip. The antennae are short, appressed into vertical grooves on the face, the arista varying from plumose to entirely bare. The face is concave, not prominent, provided with vibrissae. This is a large family, the larvae of which have a tendency to feed upon decaying vegetable matter from which a number of species have adopted the habit of attacking the roots of vegetables. The cabbage maggot (page 670), the onion maggot (page 660), the seed-corn maggot (page 518), and the spinach leaf miner (page 677) are all very destructive, because of the practical difficulty of destroying them beneath the soil where the larvae live.

Family Muscidae³ (Including Calliphorinae). The House Fly Family. The best-known and most important representative of this family is the common house fly (page 1031), which is fairly typical of the entire family. These flies are rather short, weak-skinned, not very bristly but never bare, grayish or metallic blue or green, with ample wings, in which the *radial* 5 cell is either closed or narrowed at the wing margin by the forward-bent *medius* 1 and 2 vein (Fig. 20.10). Although many species have grayish or brownish pollinose markings, there are a good many in which the abdomen

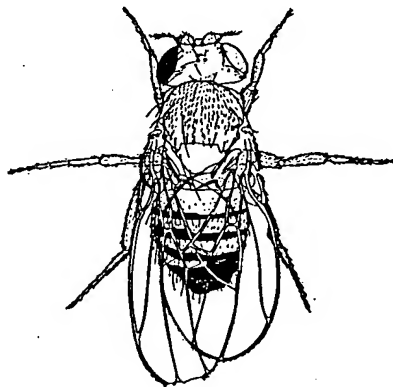


FIG. 6.109. A specimen of the common fruit or pomace fly, *Drosophila melanogaster*, that is half female and half male, a gynandromorph. The dark eye, notched wing, and shape of the abdomen on the left side are those of a female, while the broad wings, color and character of the eye, gnarled or twisted bristles, and other characteristics of the right side show that this half is male. (From T. H. Morgan, C. B. Bridges, and A. H. Sturtevant, "The Genetics of *Drosophila*.")

¹ MORGAN, T. H., C. B. BRIDGES, and A. H. STURTEVANT, "The Genetics of *Drosophila*," *Bibliographia Genetica*, II, 262 pp., 1925; DEMEREC, M. (ed.), "Biology of *Drosophila*," 632 pp., Wiley, 1950; STURTEVANT, A. H., C. B. BRIDGES, T. H. MORGAN, L. V. MORGAN, and JU CHI LI, "Contributions to the Genetics of *Drosophila simulans* and *Drosophila melanogaster*," *Carnegie Institution of Washington, Publ.* 399, 1929.

² JOHANSEN, O. A., "Anthomyiidae of Eastern United States," *Trans. Amer. Entom. Soc.*, 42:385-98, 1916; MALLOCH, J. R., "Anthomyiidae of North America," *Trans. Amer. Entom. Soc.*, 46:133-196, 1920.

³ HOUGH, G. DE N., "Some Muscinae of North America," *Biol. Bul.* 1, pp. 19-33, 1899; SHANNON, R. C., *Insecutor Inscitiae Menstruus*, 11:101-118, 1923, and 12: 67-81, 1924; HEWITT, C. G., "The House Fly: A Study of Its Structure Development, Bionomics and Economy," Manchester Univ. Press, 1910; WEST, L. S., "The House-fly," Comstock, 1951.

or thorax and abdomen both are shiny green or blue. The arista is generally plumose full-length, which, with the absence of large bristles on the abdomen except at the tip, will separate them from the Tachinidae. The eyes of the males are close together or touching on top of the head. The mouth parts are of distinctly different types, most of them being sponging in type (Fig. 4.15). A number of species, however, have developed a bloodsucking habit with mouth parts adapted for piercing animal flesh and sucking blood (Fig. 4.8). In these species both males and females feed on blood. These include the stable fly (page 942), the horn fly (page 954), and the tsetse flies of Africa (*Glossina* spp.),¹ carriers of the fatal sleeping sickness (page 29). The size range is a little smaller than the Sarcophagidae. Most of the larvae develop in decomposing animal or vegetable refuse. Some attack living animals, especially living in wounds, as the screw-worm flies (page 968), or upon helpless young, like the nestlings of birds. The bluebottle flies, blowflies, and the cluster fly, *Pollenia rudis*, are very common in and about human habitations.

Family Sarcophagidae.² The Flesh Flies. Although as a group the flesh flies are rather distinct in appearance from the house fly group, the best technical distinction from the Muscidae appears to be that

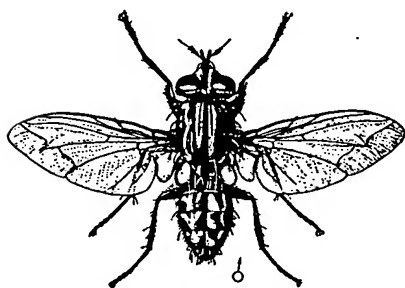


FIG. 6.110. *Sarcophaga kellyi*, male, a parasite in the larval stage in grasshoppers. About 6 times natural size. (From U.S.D.A., Farmers' Bul. 747.)

in this family the arista is plumose only on the basal half, the tip being bare, whereas the Muscidae have it plumose to the tip. Except in the matter of the elbowed *medius* 1 and 2 vein, these flies are very similar also to the Anthomyiidae. The typical color is grayish, somewhat longitudinally striped with white on the thorax, and spotted with the same gray or white pollen on the abdomen. These whitish pollinose markings are generally more prominent than in either the Muscidae or the Anthomyiidae. The abdomen tends to be longer than in the Muscidae (Fig. 6.110). Vein *medius* 1 and 2 bends sharply forward, nearly or entirely closing cell *radius* 5. The size range of common species is from $\frac{3}{16}$ to $\frac{1}{2}$ inch long. Many of the larvae are parasitic upon such insects as grasshoppers, caterpillars, and beetles. Some of the species attack their victims while both insects are in flight and deposit already hatched larvae on their bodies—an ancient example of aerial warfare. Others develop in the carcasses of animals or in dung or garbage or live in wounds or in the nasal passages or stomachs of larger animals.

Family Tachinidae.³ Tachinid Flies. Superficially resembling the house flies and flesh flies in wing venation and the presence of large tegulae, these may best be distinguished by the entirely bare arista and the presence of large bristles on the base of the abdomen (Fig. 2.16). They are in fact very bristly, usually robust but rarely slender flies, common on leaves or about flowers, from which the adults get their food. They fly swiftly and in general give the impression of being abundantly able to take care of themselves. The veins tend to retreat a little from the posterior margin of the wings. The legs are stout and bristly. They are much more diverse in the structure of the head and antennae and more interesting to the systematist than the Muscidae or Anthomyiidae, some of them being handsomely marked with yellow or with whitish

¹ AUSTEN, E. E., "Monograph of Tsetse-flies," British Museum, 319 pp., 1903; NEWSTEAD, R., A. M. EVANS, and W. H. POTTS, "Tsetse-flies," *Memoir Liverpool School Tropical Medicine* (n.s.), vol. 1, 268 pp., 1924.

² ALDRICH, J. M., "Sarcophaga and Allies," Thomas Say Foundation, 302 pp., 1916, and *Proc. U.S. National Museum*, vol. 78, no. 2855, 1930; HALL, D. G., "Blowflies of North America," Thomas Say Foundation, vol. 4, 477 pp., 1948.

³ COQUILLETT, D. W., "Tachinidae of America, North of Mexico," *U.S.D.A., Div. Ento. Tech. Ser. Bul.* 7, 1897; CURRAN, C. H., "Tachinidae," *Bul. Amer. Museum Natural History* 89, art. 2, 122 pp., 1947.

or golden pollen. The family is in his combat with crop pests, although various beetles, Hymenoptera, and other insects have attacked (page 68). The eggs where they may be eaten by hatched are thrust beneath the forming an organic connection tissues, which grow inward from round the larvae for at least a desert the mortally injured host.

Family Oestridae.¹ (Including bot-flies are well known to all who bee-like flies that chase or irritate, dashing against their legs, through the hairs in these regions. The and is nearly hemispherical, and insects are not bristly, but are contrasting colors. The antennae, never large. The eyes are as in Muscidae, except in the *medius* 1 and 2 runs straight to in the horse bots than in the other large, very spiny, fat maggots, especially mammals. The best live as maggots in the alimentary or cattle grubs (page 963), the the back of cattle and bison; and sheep. The rabbit bot, *Cutere* the emaculating bots live in the and other species occasionally soil, and there is usually one g

Family Hippoboscidae.² Lo upon the skin, among hairs of The best-known is the sheep tick the wool of sheep. Less well-known and other birds. Some have come time. A few have them preserved wings which have the veins of which they make quick short flights of the body is little fly-like. The legs widespread, with the coxae have nearly or quite disappeared like that of a tick. The head the eyes are small, far separated the mouth, seem to consist of a retractile, piercing mouth style palps. There is a broad band are strong and bristly; the clasp triple. Even the halteres have The family is a small one but natural degeneration that has appeared of their peculiar method of reposed, one at a time, in the ut

¹ HERMS, W. B., "Medical E

² SWENK, M. H., "North American Hippoboscidae," *Parasitology*, 14:1 Wisconsin," *Bul. Publ. Museum*

or golden pollen. The family is considered to be one of the most helpful allies of man in his combat with crop pests. Most of the larvae live in and destroy caterpillars, although various beetles, Hymenoptera, flies, true bugs, and Orthoptera are also attacked (page 68). The eggs are glued to the skin of the host or laid upon foliage, where they may be eaten by the host caterpillar when it feeds, or larvae already hatched are thrust beneath the skin of the victim. The larvae are remarkable in forming an organic connection with the host, consisting of a sheath formed of the host tissues, which grow inward from the body wall or from a trachea and completely surround the larvae for at least a part of their life. For pupation the larvae usually desert the mortally injured host and enter the soil.

Family Oestridae¹ (Including Gastrophilidae and Cuterebridae). Bot-flies. The bot-flies are well known to all who work with domestic animals as the large, very hairy, bee-like flies that chase or irritate cattle, horses, and sheep on hot summer days by dashing against their legs, throats, or mouths, in their attempts to glue eggs fast to the hairs in these regions. The body is very broad. The head hugs the thorax closely and is nearly hemispherical, with a broad retreating hairy face (Fig. 20.17). The insects are not bristly, but are usually densely covered with short fine hairs often of contrasting colors. The antennae are short, almost hidden; the mouth parts degenerate, never large. The eyes are rather small, well separated in both sexes. Wings are as in Muscidae, except in the horse bots, where cell *radius* 5 is wide open because vein *medius* 1 and 2 runs straight to the wing margin. The tegulae are also much smaller in the horse bots than in the other Oestridae. The larvae of bot flies (Fig. 20.9) are large, very spiny, fat maggots that live in some part of the body of vertebrate animals, especially mammals. The best-known species are the horse bots (page 948), that live as maggots in the alimentary canal of horses, mules, and donkeys; the ox warbles or cattle grubs (page 963), that live in tumors which they produce under the skin of the back of cattle and bison; and the sheep bot (page 982), which mines in the heads of sheep. The rabbit bot, *Cuterebra cuniculi*, forms lumps in the necks of rabbits, and the emasculating bots live in the scrotum of squirrels. The human bot fly (page 1031) and other species occasionally attack man. Pupation invariably takes place in the soil, and there is usually one generation a year.

Family Hippoboscidae.² Louse-like Flies. The adults of this family live like lice, upon the skin, among hairs or feathers of mammals and birds, sucking the blood. The best-known is the sheep tick (page 976 and Fig. 20.22), which is common among the wool of sheep. Less well-known species are found upon horses, deer, hawks, owls, and other birds. Some have completely lost their wings; others shed the wings after a time. A few have them present as vestiges, but most of the species retain ample wings which have the veins concentrated and heavy in front but faint behind, with which they make quick short flights in search of a hairy or feathery host. The form of the body is little fly-like. The thorax and abdomen are very broad and flattened, the legs widespread, with the coxae far separated. The marks of abdominal segments have nearly or quite disappeared, and the skin has become very tough and rubbery, like that of a tick. The head is closely packed against a concavity of the prothorax; the eyes are small, far separated; the antennae, which are sunken into cavities above the mouth, seem to consist of a single segment with a dorsal or terminal bristle. The retractile, piercing mouth stylets are shielded, when protruded, by the stiff, elongated palps. There is a broad band of sternum between the right and left coxae; the legs are strong and bristly; the claws very well developed, each one sometimes double or triple. Even the halteres have become rudimentary or, in some species, entirely lost. The family is a small one but possesses great biological interest because of the structural degeneration that has apparently resulted from their parasitic habits and because of their peculiar method of reproduction. No eggs are laid, but the larvae are developed, one at a time, in the uterus of the female fly, being nourished by a milk-like

¹ HERMS, W. B., "Medical Entomology," 4th ed., Macmillan, 1947.

² SWENK, M. H., "North American Hippoboscidae," *Jour. N.Y. Ento. Soc.*, 24: 126-136, 1916; FERRIS, G. F., and F. R. COLE, "Contribution to Knowledge of Hippoboscidae," *Parasitology*, 14:178-205, 1922; MACARTHUR, K., "Hippoboscidae of Wisconsin," *Bul. Publ. Museum Milwaukee* 8, pp. 373-440, 1948.

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secretion of the accessory reproductive glands. When full-grown they are extruded and glued fast to the hairs or feathers of the host (Types of Reproduction, page 157). The larvae are yellowish white, without legs, distinct segments, or mouth parts, with a black "button" surrounding the spiracles at the posterior end of the body. They take no food after birth but are cemented to the hairs or feathers of the host and very soon form a brown seed-like puparium. Within the puparium the pupal stage is passed, and from it an adult presently clambers out. The pigeon louse-fly, *Lynchia brunnea*, is a winged species, imported from Europe, but now widely distributed in North America. It is the carrier of a protozoan disease, pigeon malaria.

Family Braulidae.¹ The Bee Louse. These insects are so remarkable that they are included for description, briefly, although there are only two known species in the family and they are only about $\frac{1}{16}$ inch long. The bee louse, *Braula coeca*, is a tiny, wingless, big-legged, louse-like, degenerate fly that develops in the nests of the honeybee. They live as adults, upon the body of the queen and drone bees, securing, as food, honey from the bee's mouth. The eyes are very small; the head very broad between them. There are no ocelli, and the mouth parts are similar to those of the Hippoboscidae. There are neither halteres nor any trace of wings. The thick legs bear on the last tarsal segment a pair of comb-like structures. The insect lays its eggs among the bees' comb, and the larvae, which are typical maggots, tunnel through the wax caps of comb honey and feed upon the food stores of the bee.

ORDER SIPHONAPTERA (APHANIPTERA OR SUCTORIA)²

THE FLEAS

This is a very small order, very well defined, and not closely related to any other group of insects. All the species are wingless, and all are, in the adult stage, external parasites on warm-blooded vertebrates. They are facultative rather than obligatory parasites (page 63). They are almost unique among insects in being flattened, or thin, from side to side, like a sunfish. The legs are long and adapted for jumping, and the coxae are abnormally large, often being actually the largest segment of the leg (Fig. 21.9).

The body wall is hard or tough, polished, and provided with many backwardly directed hairs and with short, stout spines, often arranged so regularly as to resemble combs.

There are no compound eyes, and often the simple eyes also are wanting. The three-segmented antennae are concealed in grooves just behind the eyes (Fig. 4.9, A).

The mouth parts (Fig. 4.9) are piercing-sucking in type, but differ from any of the other subtypes in having two pairs of palps and the maxillae not stylet-like. The mandibles and labrum-epipharynx are adapted as stylets for piercing and forming the salivary duct and food channel; the maxillae are broad, triangular plates that do not enter the wound but do bear segmented palps. Another unusual feature of the fleas is that the three segments of the thorax are very distinct and free from each other.

These are almost the only external insect parasites of our larger animals that have a complete metamorphosis. The adult stage is the only stage that is recognized generally. The eggs are not fastened to the host, like the eggs of lice, and so are not noticed. They drop off the host or are laid on the floor of the nest, kennel, or dwelling of the host.

¹ PHILLIPS, E. F., "The Bee-louse in the United States," *U.S.D.A. Cir.* 334, 1925.

² FOX, I., "Fleas of Eastern United States," Iowa State Coll. Press, 1940; FOX, I., and H. E. EWING, "Fleas of North America," *U.S.D.A. Misc. Publ.* 500, 128 pp., 1943; HUBBARD, C. A., "Fleas of Western North America," 533 pp., Iowa State Coll. Press, 1947.

The larvae that hatch from the cylindrical, whitish maggots with a dark spot but no ocelli and no legs. They have no addition to the head. There are no thoracic and abdominal segments, a band of very long, stiff hairs. They are such dead animal and vegetable matter or in the dirt about the sleeping of the host they spin a cocoon of silk, cover the pupa is formed. The pupa has no body, absence of wings, inconspicuous than the head, and mandibles of the pupa are free from the body.

Small, laterally compressed, jointed, spiny, and in the adult stage living on animals. Compound eyes small, situated in grooves; no neck. Mouth parts without palps. Thoracic segments distinctly nearly contiguous; hind legs with claws strong. Cerci minute. Male slender, cylindrical, without legs, chewing mouth parts, and spiracles scarcely $\frac{1}{2}$ inch long, with transverse without wings, enclosed in a cocoon.

The only families of much importance

The common fleas, Family *Pulex*
The sticktight or chigoes, Family *Trichodactylidae*

The fleas of the first family are pests of cats, dogs, and hogs, of man and seriously annoying the person also especially as the known cause of plague and endemic typhus (page 63). The sticktight flea, that attaches to the host and is fixed in this position sucking the blood of the host, the females of which are of man, especially about the face, are enormously in size, causing bad

¹ Not to be confused with the chigger.

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